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ABSTRACT

Intended to encourage elementary teachers to explore coastal ecology with their students, this guide presents background material, activity suggestions, and recommended resource materials that could be used in designing a week-long unit on Coastal Awareness. Discussed is how various physical processes such as waves, tides, and currents affect sandy beaches, estuaries, rocky shores, and marshes. About 20 related activities are described. Included in the resource materials section are an annotated bibliography and film list, information sources, and Sea Grant institutions. (WB)

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Coastal Awareness:

A Resource Guide For Teachers in Elementary Science

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Coastal Zone Management

September 1978
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FOREWARD

This series of Resource Guides on Coastal Awareness in Science was developed for elementary, junior high and high school teachers who would like to instill in children and young adults an appreciation of the ecologic value of the coast. Each of the Guides contains concepts, and activities which could be used in a week long unit on Coastal Awareness. The purpose of this guide is not to present a definitive work on coastal ecology, but to entice teachers to explore ecological aspects of coastal awareness. A more complete understanding of the coast requires study of the interactions of ecology with economics, humanities, and government.

As state governments develop coastal management programs, citizens must make choices as to the most important uses of the coast. An understanding of coastal ecological processes will aid students as they participate in future decision making.

The Coastal Awareness Series in Science includes:

Coastal Awareness in Elementary Science
Coastal Awareness in Junior High Science
Coastal Awareness in Seniro High Science

These are available from the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, 3300 Whitehaven Street, N.W., Washington, D. C. 20235.

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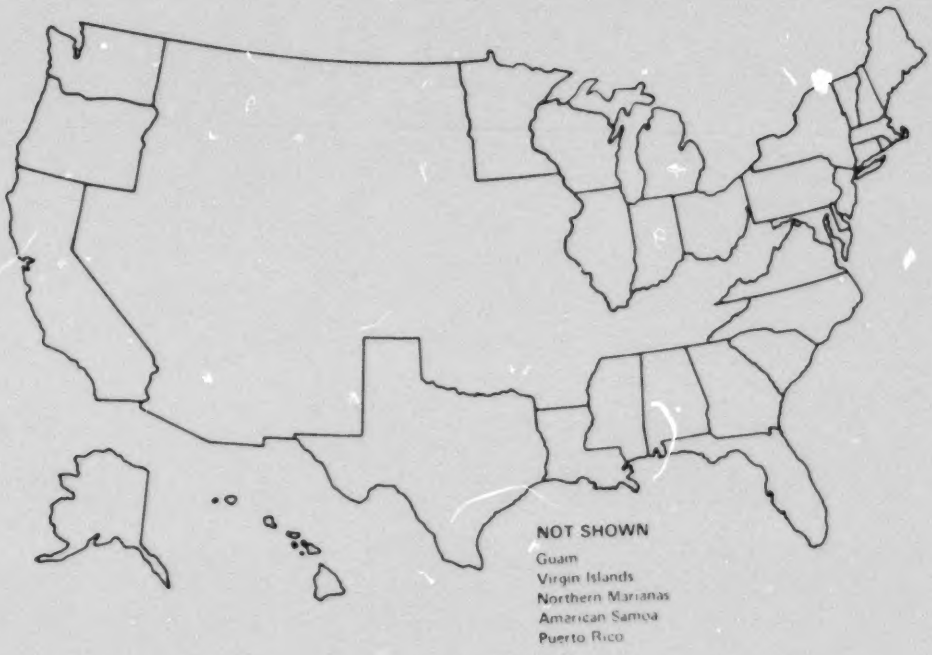
THE CHARACTER OF THE COAST



THE COASTS

The shore lines of the United States--where the land meets the sea--measure more than 140,000 km (88,000 mi). If straightened, they would stretch more than three times around the equator of the earth. Our nation's coasts include the sea shores of the continental United States, Alaska, Hawaii, four Atlantic island groups, and nine Pacific island groups. The Great Lakes and all the sounds, bays, creeks, and rivers washed by tidal waters are also included.

What are the special characteristics that define a coast, that make coasts valuable and vulnerable to human activities? Why and how should we protect this vital area of our nation?

The coast is a place of untold natural resources. It is a place to which one can escape, a place to play, to be serene, to be inspired. In near-shore ocean waters fish can be caught for sport or for food, and the coast itself can be a significant agricultural area. Each coast has a different history, different pressures, and different problems. Yet, in a physical sense, many of their problems may be similar.

Pollution is one such common problem. The Great Lakes are the largest fresh water resource in the world. Pollution of these lakes, which began in the 1800's, has continued steadily: forests were cleared, disrupting the natural balance, and increases in population, industry, commerce, and recreation continue to encroach.

The development that has plagued the Great Lakes for a century is only just beginning in Alaska. But changes come quickly where the margin for life is narrow, and in the frigid waters of the Bering Sea there is little room for error. The Bering Sea is literally the "fish basket" of the northern hemisphere. It supports a surprising variety of life, including one of the largest marine mammal populations of the world, what may well be the world's largest clam population, one of the world's largest salmon runs, some of the largest bird populations per unit area, the world's largest eelgrass beds, and unusually high numbers of bottom-dwelling fish.

Any coast consists of two primary elements: the water and the land. The area where these meet--the coast--has unique characteristics due to periodic inundation and continual changes in salinity. The biological composition of the coasts is often in delicate balance.

The science student concerned with the coastal zone will want to investigate both the water and the land as well as their interaction. Coastal waters are generally rich in nutrients that have been carried from the land by the rivers and streams. Near-shore coastal waters are particularly productive. These waters are a basic resource; they are affected by a variety of factors--the forces that cause tides, the winds that augment the waves, and the activities of human beings, including exploration and exploitation.

THE SHORE

There can be other definitions, but for our study, we define the shore as the narrow strip between the high-water and low-water marks of spring tides. Thus, there are regular, yet extremely variable local environments. First, the sea covers and uncovers the coastal area twice daily. Temperature ranges may be great within a single day. The salt concentration may vary greatly. The extent to which this intertidal zone is uncovered at low tide depends on the sharpness of its slope which in turn depends on a variety of factors including the nature of the land, its configuration, and the action of the tides, currents, and rivers.

The three basic types of shore are rock, sand, and mud. They are often mixed together. The waves have the greatest influence on molding the shore as they break against the land, washing away loose materials, eating into hard rocky coasts, and sometimes forming an abrasion platform at the base of high cliffs. Powerful crosscurrents deposit banks of sand that have been formed by the disintegrating rocks. Mud flats occur at the mouths of rivers or in sheltered creeks and inlets where the sediment brought from the land is deposited. Ice, weather, and the elements all work to help form the shore.

Plants and animals are other factors in coast building. Plants may act to bind sand and mud together into dry land. Encrusting animals may serve to protect rocks or to destroy them. Light plays a significant role in this environment, affecting growth of vegetation which, in turn, affects animal growth and survival.

Estuaries, too, affect the shore environment. Dilution by fresh water will occur at the mouths of rivers, while increased concentrations of salt will occur as a result of evaporation during the summer.

OCEAN IN MOTION: WIND, WAVES, CURRENTS AND TIDES

Wind generates waves. The wind, blowing irregularly, causes significant pressure differences that deform the water's surface, creating wave crests of many heights. The wind then pushes against these crests, supplying energy to the waves as they grow and become more regular in height and length. Wave growth depends on four factors: wind velocity, distance of open water over which the wind has blown (called the "fetch"), duration of the wind, and the state of the sea (waves that were present when the wind started blowing).

The wind also plays a part in coast formation. In addition to their indirect effect through action on the water, powerful winds can cut into rock, tearing away gravel that slides to the water's edge. They may also pick up grains of sand and pile them into dunes.

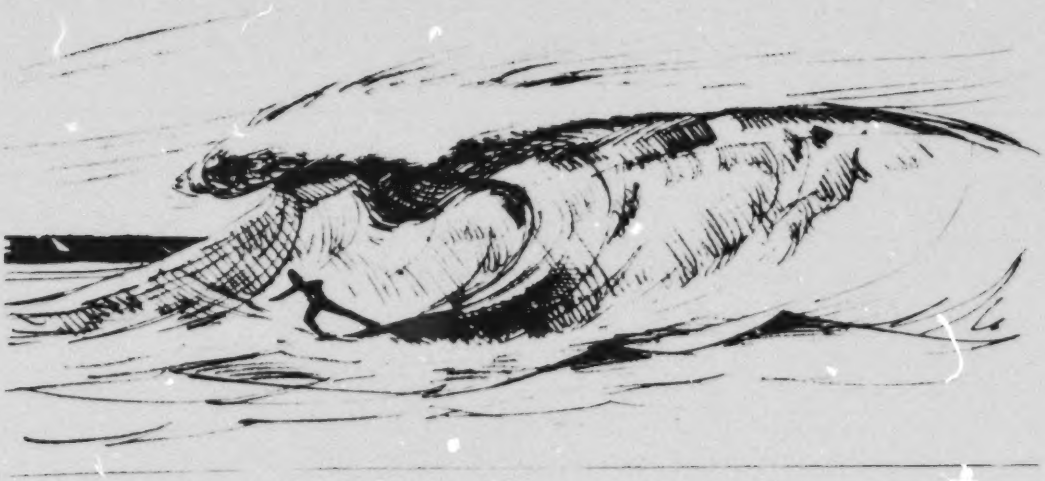
WAVES

Waves are the sculptors of the coasts. Forceful or gentle, loud or lulling, they combine two distinct types of motion. One is the circular motion of the water molecules within the wave, the up and down motion of the droplets. The other is the advancing movement. The actual water molecules have no horizontal motion as the wave advances through the ocean.

Waves are described by their height, length, velocity, and period. Period is the number of seconds it takes for two successive crests to pass a stationary point. Height is the vertical distance from the crest (high point) to the trough (low point) and length is the distance from one crest to the next. Period, length, and wind velocity are interrelated. Wave height, however, is not related to these factors. The height of a wave in meters is usually about one-tenth the wind's speed in kilometers per hour.

As they move away from the winds that started them, waves tend to expand laterally and to become lower, more rounded, and more symmetrical. They then move in groups of similar size, called "wave trains"; the individual waves are called "swells." Once a wave train has formed, it will continue to travel over the sea until it either breaks on a shore or is flattened by opposing winds or wave systems. (In these materials, we will be concerned in particular with the breakers because of their effect on the coastal area.) As a swell approaches the beach, the topography of the ocean bottom takes effect. Depending on wave length and bottom contour, waves may break at depths from one-half to three times their height.

The bottom slope is the key determinant not only of the depth at which a wave breaks but also of the manner in which it breaks. A steep bottom results in a wave that retains all its energy until the last possible moment, when the crest peaks up suddenly and plunges violently forward into the trough. As the crest folds over it becomes concave, creating a "tube" or tunnel of air on the shoreward face. These are known as "plunging waves." Hollow plunging waves are the most challenging for surfers because their steepness makes for a very fast ride and it is often possible to crouch under the falling crest--to be "locked in the tube." The plunging waves that curl over the dangerously shallow coral reefs of Hawaii's "Banzai Pipeline" are a famous example of this kind of wave.



A gradually shoaling bottom results in a wave that releases its energy more slowly. When a crest finally becomes unstable, it rolls down or spills into the trough and the wave face remains gently sloped. It is these "spilling waves" that display white water at the crest.

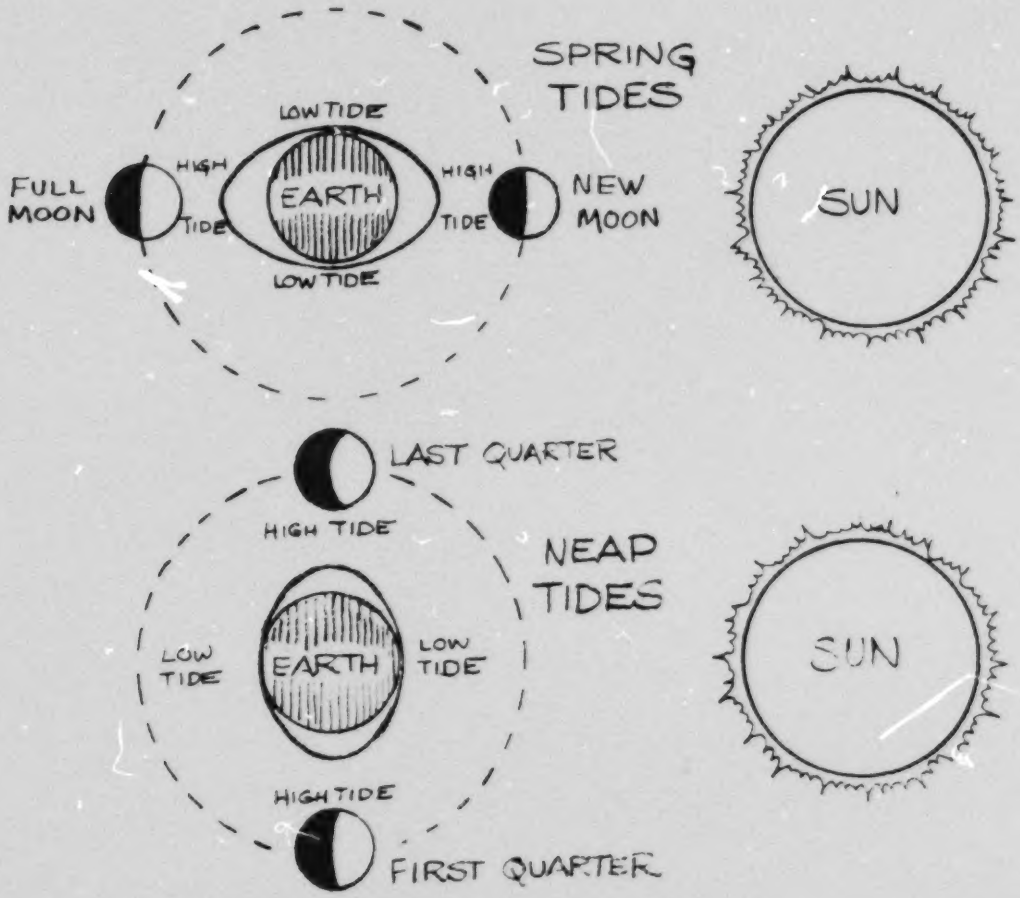
Irregularities in the ocean bottom tend to make waves spill rather than plunge. Even long-period waves break as spillers on a flat sloped beach, but any suddenly shallow spots will cause most waves to "suck out" and plunge, regardless of their periods. Most surf zones are in a state of constant change.

Wind is not the only generator of waves. Earthquakes on the land or under the sea may cause a drastically low tide that is followed by destructive giant waves (sometimes called tsunamis) hurling relentlessly against the shore.

TIDES

The tides are important in determining the character of the coast. Tides result from the effect on the waters of the gravitational attraction among the sun, moon, and earth.

The masses of the earth and the moon exert a gravitational pull on each other that affects every particle on earth, including water. The force is greatest on those particles nearest the moon, but it is much smaller than the earth's force. Although the force required to pull water vertically off the earth would be great, a much weaker force can pull the water horizontally, in effect sliding it across the face of the earth. Water is drawn toward the point directly "below" the moon, and high tides occur when water piles up in this way. Identical forces cause comparable effects on the side of the earth farthest from the moon. In both cases, the water moving into the high tide is being drawn away from another region of the earth. Thus, there are high tides on opposite sides of the earth on a line directly extended between the moon and the earth, and there are low tides midway between the two high tides, in the area from which water for the high tides was drawn.



Due to the changing position of the moon, a tidal pulse sweeps around the surface of the earth, causing secondary waves that move across the oceans. In mid-ocean the secondary waves may be only as high as 1 meter, but where the water is shallow these sea waves become much higher. The increased height is the result of a tremendous friction force which slows the wave down. When such tidal pulses move through narrow channels, the water is "bottled up." The highest tides occur in these narrow channels; a well known example of such tides is the Bay of Fundy between Nova Scotia and New Brunswick in Canada.

Because the earth and the moon move orbitally (the earth around the sun and the moon around the earth), both the timing of the tides and their range vary in response to these gravitational forces. The greatest difference between high-water and low-water is found at the "spring" tide, when sun and moon exert their force in the same direction during the new or full moon. The highest tide is during the new moon when the moon is in line with the sun, with the earth between them, and the gravitational pull is all in the same direction. The smallest, or "neap" tide occurs when the high-water mark is at its lowest, and the low-water mark is at its highest.

CURRENTS

The forces that keep the great mass of ocean water in motion are many and varied; important among them are the heat of the sun and the rotation of the earth.

As the sun warms the surface water at the equator, the water expands and raises the surface just enough to cause a gentle slope. Water at the equator therefore runs downhill to the poles. The heavier polar cold water sinks and spreads slowly along the bottom of the ocean toward the equator. This interchange of warm equatorial waters with cold polar waters is complicated by a variety of additional forces. For example, the earth's motion toward the east affects the water on the surface of the earth both directly, by causing waves to pile up, and indirectly, by creating winds. The spin of the earth also results in the Coriolis effect -- the tendency of water (or any moving object) to turn slightly to the right in the northern hemisphere and slightly to the left in the southern. Consider the Atlantic Ocean waters in the region just north of the equator, where the Gulf Stream originates. Heated by the tropical sun, the salt concentration of the water steadily increases as a result of constant evaporation. Meanwhile, the trade winds (a consequence of the earth's spin) continually blow over the warm, salty waters, pushing the surface waters in a westerly direction toward the north coast of the South American continent. The waters then move toward the Caribbean Sea and on, northwesterly, into the Gulf of Mexico where they pile up, raising the surface level. Following its natural tendency to seek equilibrium, the water drops into the Florida Straits, the only possible egress. From there the Gulf Stream runs northward along the coast.

As the Gulf Stream moves north it trends increasingly toward the right (to the east) because of the Coriolis effect. By the time it reaches 40° N latitude, it is flowing due east across the Atlantic, has lost considerable speed, and has widened; it has also cooled down. Currents similar to the Gulf Stream move the waters of the Pacific, Indian, and other oceans.

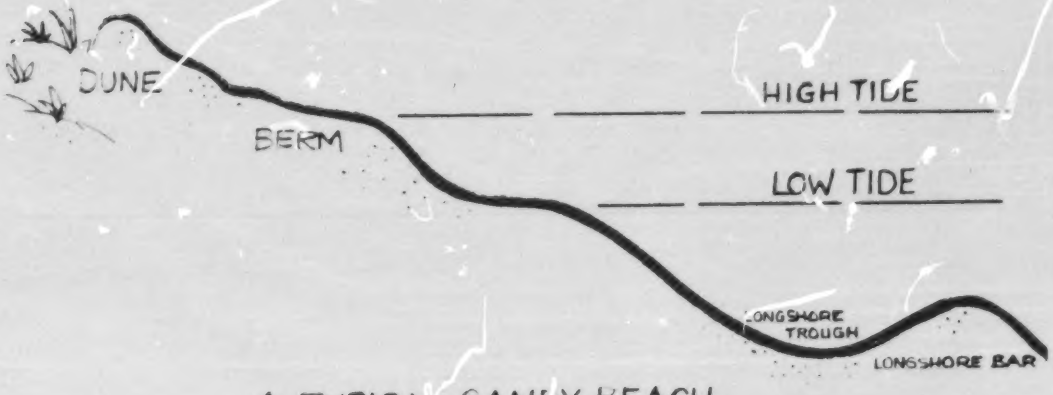
Other factors affecting water currents include ice floes moving from polar seas on the cold currents. As the ice moves southward it cools the water. Since cool water is heavier than warm water, it sinks and is then replaced by warm water near the surface.

The most economically important currents are upwellings of cold bottom water. This vertical motion brings to the surface an unusually heavy concentration of nutrients. When offshore winds drive surface waters out to sea, they are replaced by the upwelling nutrient-rich deep water. Mineral-rich waters from the land add to the nutrient supply. This upwelling supports a rich growth of phytoplankton, the start of a complex food chain, and makes possible intensive commercial fisheries such as those off the coast of Peru and the Grand Bank off the coast of Newfoundland, Canada.

THE SANDY BEACH

Of all the coastal elements, sandy beaches probably have the highest recreational value. These beaches vary considerably from one part of our

country to another. They have different sand, different waves and winds, and different dunes and other inland formations. They are composed of grains as diverse as the black lava sands of Hawaii, the golden sands of Lake Michigan, the white coral sands of Florida, and the seemingly endless sandy expanse from San Diego to Los Angeles. Florida's popularity as a vacation land almost certainly is in large part due to the fact that so much of its coastline is sandy ocean beach.



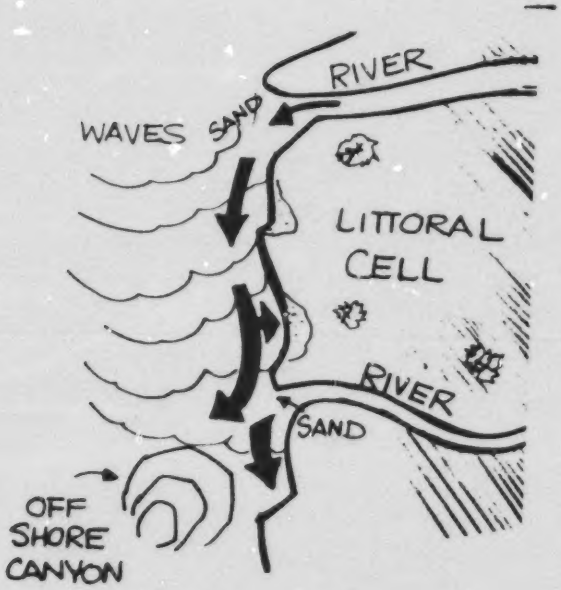
A TYPICAL SANDY BEACH

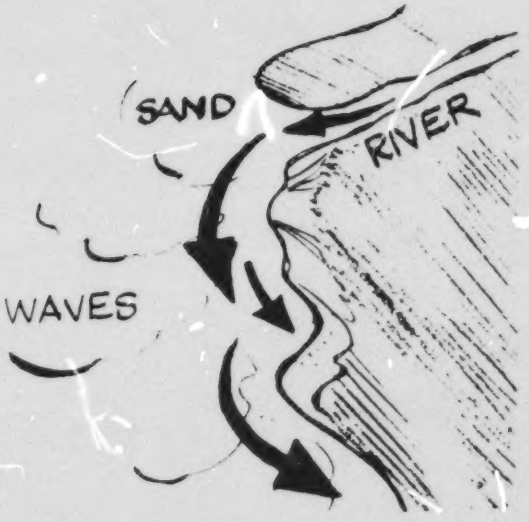
Although sandy beaches differ in many ways, they also share certain characteristics. A cross section of almost any sandy beach in early summer would probably reveal a structure like that shown above. Waves moving onshore break on the longshore bar and roll up onto the beach. Each wave moves sand from the longshore bar and slowly, almost imperceptibly, a longer more sloping beach is created. Then, as the season changes, blustering winter winds and heavy seas begin to attack the sloping summer beach. The winter waves are higher, steeper, and closer together than those of summer. Sometimes sand is carried away from the berm and even from the dunes or other land areas behind the berm. This pounding winter wave action generally deposits some sand on the berm, but it carries away far more sand and deposits it in longshore bars, setting the scene for another yearly cycle.

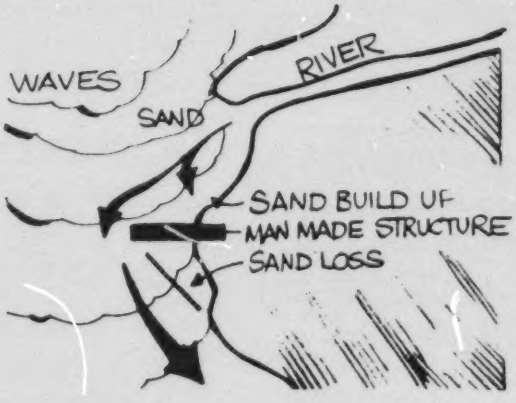
The texture of the sand plays a role in the kind of beach that will be built, because the slope of the beach relates directly to the particle size of the deposited material. The coarser the particles, the more the waves sink into the beach, depositing their load of sand. Since coarse sand does not pack down and is easily moved around, steep beaches result. When the particles are finer the sand packs down more tightly; the waves do not sink in, and their action leaves a harder, smoother, and gentler slope.

Waves and wind thus work endlessly building, shaping, and reshaping beaches. Large particles grind against each other, creating progressively smaller fragments. The largest of these are dropped on the beach and smaller less dense particles are carried out to be deposited in quieter, deeper regions of the ocean.

Regardless of the season, the markings on sandy beaches are intriguing. The graceful swash marks left by an ebbing morning tide are composed mostly of detritus -- fragments of once living things --that are not only a source of food for many beach inhabitants but are also a treasure trove for human beach explorers. Parallel ridges and troughs, called ripple marks, are often seen on sandy beaches: if the ripple marks are in dry sand they were caused by wind, but if they are lower down on the beach they were caused by moving water. Whether caused by wind or water, the process of ripple formation is essentially the same. When wind or water moving over the sandy surface meets an obstacle in the surface it turns downward, excavating a trough. The sand thus thrown up creates another obstacle and the wind or water then creates another trough.







LITTORAL CELL LONGSHORE MOVEMENT

Ocean beaches are moving, active places that gain and lose sand continuously. Beach sand is transported by waves, wind, and wave currents in three kinds of movements: offshore, on-shore, and longshore. When put into suspension by wave action, sand can move laterally along the shore in long-

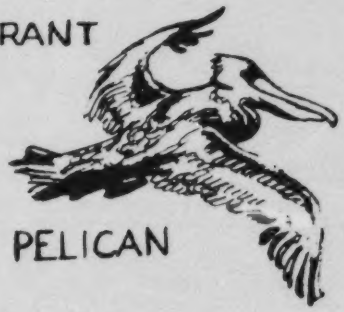
shore currents at the same time that it is being moved offshore and returned onshore. Sand movement along the shore occurs within relatively distinct sections of the coast, sometimes called "littoral cells." The boundaries of a cell extend from the place where sand is introduced onto the shoreline (generally by a stream) to the place where it is swept out to the sea. Where beach indentations in the coast are isolated from the general sand movement of the "cell" within these areas, shore erosion and onshore currents can supply sand to smaller "pocket" beaches.

Human activity often has had disastrous effects on the natural supply of sand to beaches. Reducing high water runoff from rivers seriously reduces the sand supply available since it reduces the erosion along river banks. Improper construction of groins, jetties, and breakwaters can change the distribution of sand by longshore currents, causing excessive sand build-up in some places and sand loss in others. The biological production of shorelines is also affected when normal water circulation patterns are changed. Careful study is needed before any major beachfront modifications are undertaken.

The long stretches of sun-baked sand and the breaking waves that delight vacationers are also what make sand beaches among the most barren of coastal environments. Because of its shifting nature, the sand offers a poor substrate for anchoring plants. Thus, beaches essentially lack the producers in the food chain and the few animal residents of the sand must depend on small wave-borne particles for food. Usually such residents are tiny crustaceans or mollusks which live in the moist upper surface of the beach close to the water line and filter the food from the retreating waves. Other crustaceans and sand hoppers inhabit the upper beach, feeding at night along the tide line. Each sunrise they dig new burrows often peppering the sand with their holes.

Sand beaches are superb places for bird watching. Some birds are full-fledged swimmers and obtain their food from the ocean and the near-shore ocean bottom. Others parade incessantly up and down the beach at the water's edge in search of food. The specific kinds of bird inhabitants vary from one part of the country to another, but certain general kinds can be recognized. Medium-sized birds

CORMORANT



PELICAN

that are flying across the surface of the water or riding on it are likely to be gulls, terns, or cormorants. The cormorant is a dark bird that dives and disappears for a considerable time while swimming in search of food. Gulls and terns do not swim under water. Terns can be seen flying over the water and diving into it to catch small fish, but gulls are less likely to dive for their food. Gulls, either singly or in groups, can also be seen on the beach itself in search of food. A group of large birds flying gracefully in formation just above the surface of the water is probably a flock of pelicans.

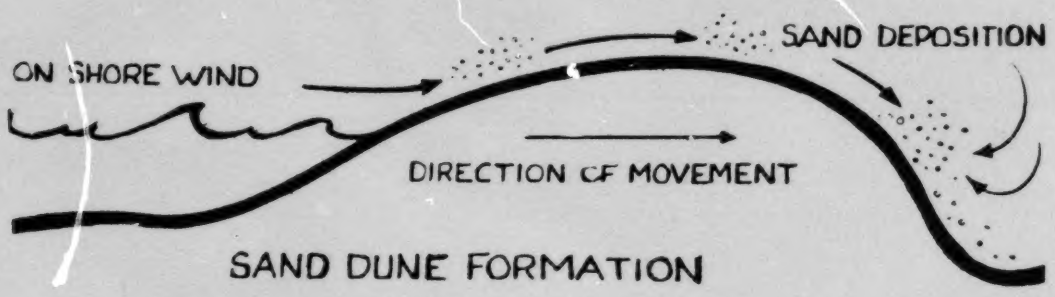
Sand pipers and plovers are the smaller birds that run up and down the beaches, carefully avoiding the breaking waves. They are generally long-legged, small to medium in size, and inconspicuous in color. Their food consists of animal and plant fragments that have been cast onto the sand by waves and the tiny animals that live in the upper surfaces of the sand.

SHORE BIRDS

SAND DUNES

Sand dunes form when large amounts of sand are blown inland from a constant source of supply such as a beach. Where the wind is slowed by a log or clump of grass, it drops its load of sand, and a mound slowly builds up. As the mound grows, more sand is deposited behind it; growing larger and higher, the mound becomes a small hill, a ridge, and finally a dune. Wind-blown sand blowing up the face and falling down the crest gives the dune its characteristic shape -- a long sloping windward side and a steeper slope on the lee side. If nothing interferes with the wind or anchors the sand, the dune creeps inland as the wind moves sand from the windward to the lee side. The rate at which a dune advances can vary from a few centimeters to many meters per year. A fast-moving dune can bury everything in its path.

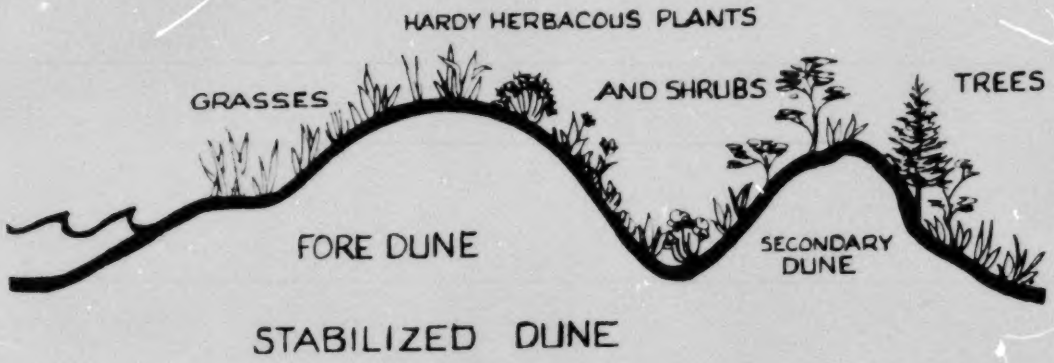
The movement of sand dunes may be slowed by the invasion of pioneer plants that can root and grow in the shifting sands; often it is grasses, such as Marran grass -- or Poverty grass -- which begin the stabilization process. After the clumps of grass have become established, shrubby plants can take root on the lee face of the dune. Protected from the wind



SAND DUNE FORMATION

and with their roots close to the water table, these shrubs often form dense thickets, providing shelter and food for small mammals and birds.

Dune life tends to progress from that of bare sand to dense woodland, but this progression can be halted and hundreds of years of growth destroyed in a very short time. Hurricanes, fires, or construction (the building of homes, cottages, or roads) can disrupt the stability that took so long to establish. When a break in the vegetation mat occurs, the wind can quickly charge through it, tearing at the roots of nearby plants. As successive clumps of plants are exposed, more and more sand is released, and the dune begins to move again.



STABILIZED DUNE

ROCKY SHORES

Rocky shores are the coastal areas where the confrontation of land (continent or island) with the ocean is most evident. Here the rocky underpinnings are ceaselessly attacked by moving water, sometimes on a spectacular scale. For example, on our Pacific shores, where wind-driven waves can build

up over almost 10,000 km (6,000 mi) of open ocean, the surf is as violent as anywhere in the world. Even normal winter storms generate 6m (20 ft) waves that break against the shore with a shock equivalent to an automobile striking a wall at about 145 km/h (90 mph).

Even though the glass beacon on Tillamook Rock light house on the coast of Oregon is some 42 m (140 ft) high, a grating had to be installed over the glass to protect it from rocks tossed up by the pounding seas. Of course, not all rocky coasts are as exposed as Tillamook Rock. Offshore islands, reefs, and headlands provide protection from the pounding surf when they are in the direction of the prevailing winds.

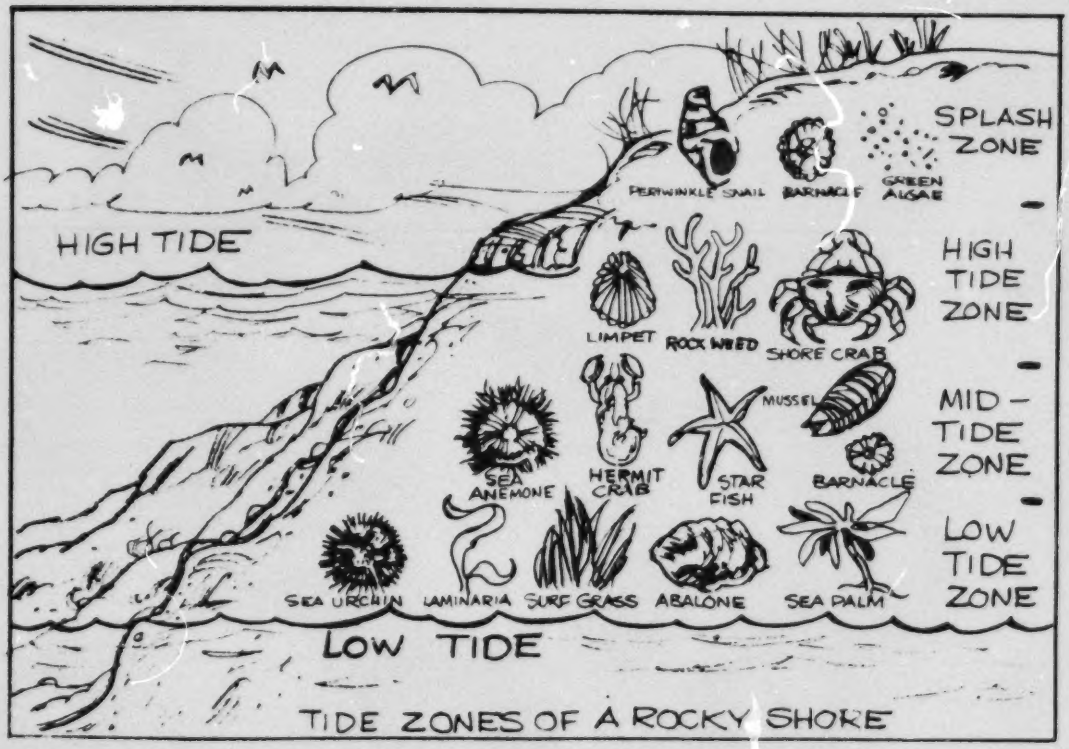
The composition of the rocky shores of the United States varies significantly from one place to another. In the northeastern United States, shorelines are made up largely of metamorphic and intrusive igneous rocks, but those on the southern Atlantic coast might be sandstone, coarse shell gravel, or coral. Continental Pacific coasts are largely sedimentary rock, and the Hawaiian coasts are igneous rock. The shores of the Great Lakes have rocky coasts, some of which are formed by older sedimentary rock and others by ancient metamorphic rock. Since the nature of the rocky substrate, the rate at which it erodes, the forms produced by erosion, and the mineral content released are so variable, it is not possible to deal with these factors in a publication of this nature. Teachers who want to explore the rocky coast should research their coastal zones in one of the publications cited in the bibliography.

The kind of biological communities that will live on any particular rocky coast is determined largely by the degree of exposure to open surf, and by the extent of tidal exposure. Life forms can vary significantly from one side of an island or a headland to the other because conditions which regulate life are so different. Regardless of their exposure to violent surf, rocky shores are much more active biologically than sandy ones, for they offer a solid, unmoving (albeit hazardous) place where both plants and animals can attach and survive. Thus, rocky shores are better than sandy ones for providing opportunities to observe a wide assemblage of marine organisms.

Significant differences in the appearance of the marine shoreline are evident at high and low tides. A careful observer can see the orderly progression of plants and animals. These species lie in horizontal "belts" across the shore, one strip above another.

In many places, these strips (or zones) are brightly colored by the resident organisms and therefore sharply delineated; a view of them from the shore is often startling. On other coasts such zones may be less obvious and more difficult to distinguish, but they are rarely absent.

Local zonation may vary considerably. Zones of a rocky face directed seaward will differ from zones facing the land or from those at right angles to the shore. Zones on a smooth, sloping rock surface may be immediately apparent whereas a shore of broken rock lying at random angles may seem not to have a pattern of zones at all. Similarly, the zones found on sunlit slopes are noticeably different from those in areas shaded by overhanging rock.



Adapted from Marine Advisory Publications

Turbulence governs the life of organisms living between tidemarks on rocky coasts. Even when the ocean surface apears to be calm, there is usually a swell which explodes when it strikes the coast. Animals that live there seem to prefer this turbulence, and the highly aerated water it produces is crucial to their existence.

Organisms living near the upper tide mark must be able to resist desiccation during low tides. Many intertidal organisms have developed anchoring methods that keep them in place even during storms which batter them for hours on end. By and large, it is the adaptation of such organisms to life under very special conditions that governs intertidal zonation.

The extreme variations found in coastal areas in the United States make it difficult to recognize the zones between tidemarks. The following definitions of the intertidal subdivisions may therefore be helpful.

SPLASH ZONE

The splash zone is the area of transition between water and land. Although it is affected by spray, it is covered by water only at the highest tides or during storms. Animals that might inhabit this area are the periwinkle snail and the pill bug.

HIGH TIDE ZONE

Where the high tide zone is most fully developed, barnacles form a dense, almost continuous sheet on the rocks. Often this sheet has a sharp upper limit which is a very conspicuous part of the shore line. On some shores limpets are present with the barnacles. Rock weed can be found in the lower edges of this zone.

MID-TIDE ZONE

Each day the mid-tide zone is usually uncovered twice (at low tide) and covered twice (at high tide). Animals found here are seldom found in the deeper waters that are not as affected by tidal fluctuation. Sea anemones, star fish, mussels, and hermit crabs are frequently found in this zone.

LOW TIDE ZONE

Only during the very lowest tides, once or twice a month, is the low tide zone exposed to view, and then only briefly. Animals found in

this zone can also be found in deeper water. The animal and plant populations of this zone are large and varied. In cold temperate regions, these populations consist of forests of the brown algae with animals and an undergrowth of small plants on their holdfasts. Coral reefs commonly include or encompass the upper edge of the rich growth that extends down the reef face below low-water level. In warm temperate regions the low-tide zone may support dense colonies of tunicates and other ascidians, as well as dense growths of red algae.

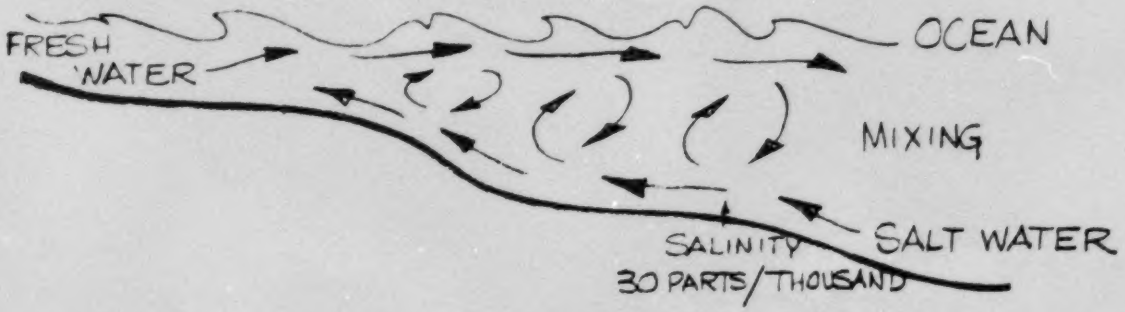
Before visiting your coast consult a local publication which describes in some detail the organisms present and their distribution. Living organisms should be observed where they are found, not collected. Disturbing the shore line in any significant way is to be avoided at all costs.

Remember that rocky coasts can be dangerous places to observe, especially at low tide when the tendency is to walk out as far as possible. Even on relatively calm days unpredictable large swells may develop, so careful watch should be maintained.

ESTUARIES

An estuary is a partially enclosed body of water connected to the open sea; thus, the seawater is diluted by fresh water draining from the land. An estuary is the site of forceful interaction between sea, land, and a

Along the coasts of the United States there are almost 900 estuaries of many different types. Along the Atlantic coast there are drowned-valley estuaries, exemplified by Chesapeake and Delaware Bays. Estuaries that developed behind barrier beaches are found at Ocean City, Maryland, and at Biscayne Bay, Florida. In contrast, the estuaries along our northwest Pacific coastline are majestic glacier-gouged fjords, where the rivers are contained by steep rocky slopes. Earthquakes, land shifts, and other violent actions have created estuaries such as San Francisco Bay.



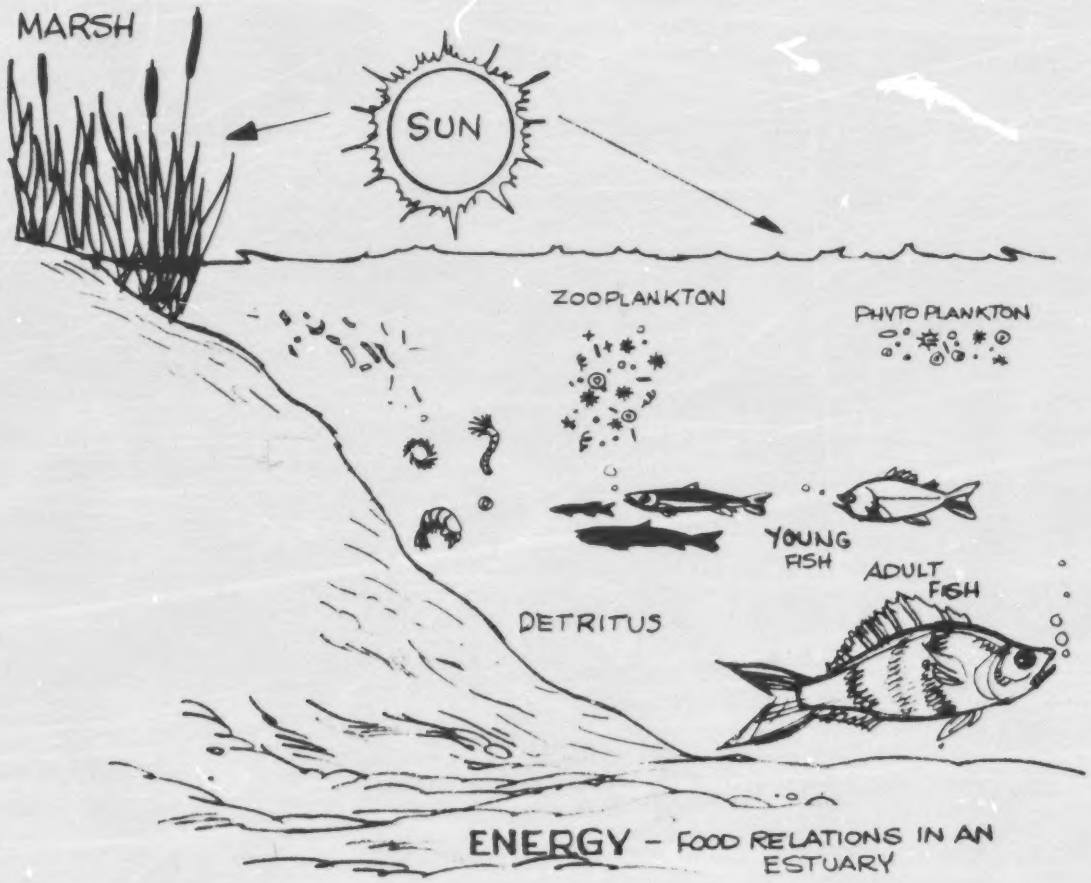
GENERALIZED CIRCULATION IN AN ESTUARY

Despite some very apparent differences, some characteristics appear to be common to estuaries: fresh water at the river end, salt water at the ocean end, and a mixing system between them. In most estuaries the salinity gradient ranges from 30 to 35 parts of salt per thousand parts of water at the ocean end and to zero salinity at the river end. Water samples from estuaries usually show that deep waters are more saline than shallow waters -- that is, a vertical gradient of salinity exists. This gradient not only moves up and down the estuary with the ebb and flow of the tide but also responds to high and low flows of river water. The net transport of the less salty water at the top is seaward, while the saltier water moves inland along the bottom. Thus, a stratified system, with a distinctive pattern of circulation evolves, resulting in the movement of surface organisms toward the sea and of bottom organisms toward the river.

Although the circulation patterns in estuaries have many characteristics in common, different estuaries may have significantly different flow patterns. For example, in the delta of the Mississippi River, the volume of fresh water is so great that the fresh water overruns the salt water of the Gulf of Mexico and a tongue of less saline water extends far out into the salty Gulf of Mexico. In Chesapeake Bay, where the outflow of fresh water and the saline tidal inflow are nearly equal, a distinct salinity gradient is formed and the water stratifies within the estuary. A variety of other factors (such as the nature and slope of the bottom, and the force of prevailing winds, the amount and timing of rainfall) also affect the circulation and salinity of estuary waters.

Rivers flowing into estuaries carry with them erosion products and detritus which tend to settle out as the current slows in the estuary. As they near the bottom, these sediments tend to be carried inland with nutrients carried in from the ocean; this creates a kind of nutrient trap that makes estuaries highly productive eco-systems. At the same time, the constant input of solid material from the river outflow contributes to the filling of the basin or to the creation of a delta extending into the sea. Unfortunately this deposition of solids also serves to trap contaminants such as heavy metals, pesticides, pathogenic bacteria, and toxins. Increasing densities of industry and population along coasts

could thus produce unforeseen but far-reaching and permanent detrimental effects on the biological production of estuaries.



ENERGY - FOOD RELATIONS IN AN ESTUARY

The food chains in estuaries include two distinct populations of primary producers -- phytoplankton and rooted aquatic plants at the edges of the estuary. The abundant zooplankton present include larvae of most of the organisms that live in the estuary. The behavioral patterns of many species of zooplankton keep them within the circulation pattern of the estuary and prevent them from being washed out to sea.

Benthos (bottom-dwelling species) are usually more abundant in estuaries than in either fresh or salt water environments. These species are quite diverse, ranging from annelid worms through a variety of crustaceans and mollusks. Many feed by various filtering processes, an effective way of trapping the nutrients flowing through the estuary. Oysters and clams are the most commercially valuable of these filter feeders harvested by man.

The benthic populations range from fresh to marine environments, but the most dense beds are often near the center of the estuarine system. The distribution of the oyster, for example, seems to be controlled primarily by three factors: the upstream limit is set by the maximum flow of fresh water from the river; the downstream limit is set by predators and parasites which are found only in high salinities; and the lateral limit depends on the presence of a relatively firm channel shoulder.

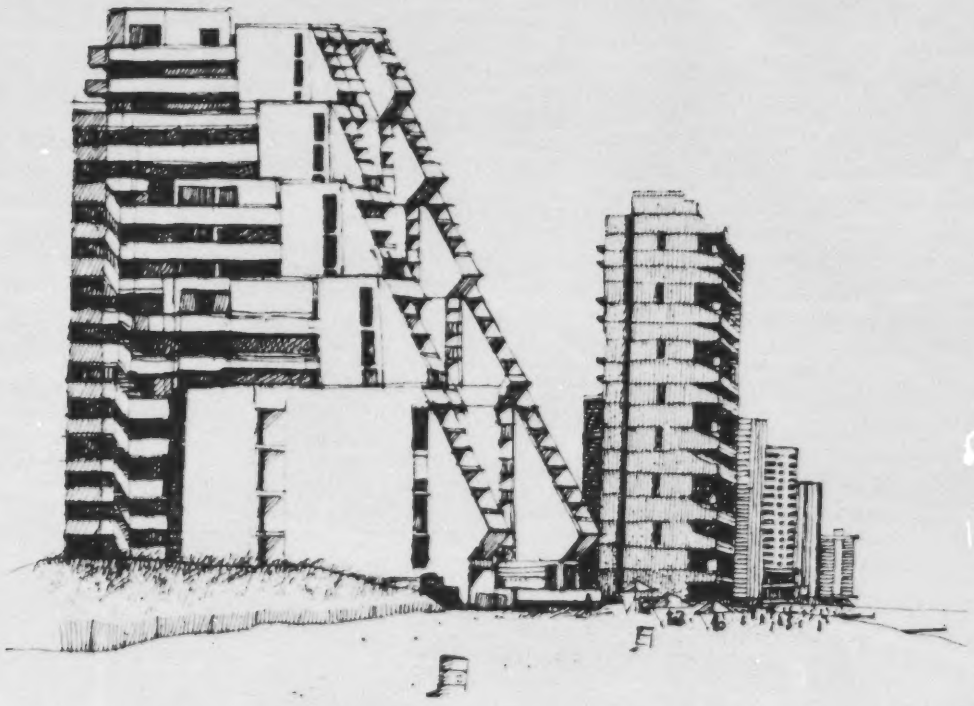
Among our coastal fishes the most commercially valuable species are either partly or entirely dependent on estuarine environments. Fish use estuaries in many different ways. Some populations of striped bass spawn near the interface of fresh and low-salinity water, others move farther into the rivers, and some populations are even adapted to fresh water. In an estuary, eggs and larvae drift downstream. The developing fish feed throughout the system until they are adults and the cycle begins again.

Anadromous fish, such as the shad or salmon, spend their adult lives in the open ocean but return to fresh water to breed. Shad also use the estuary as a nursery for the first summer before the young fish move to the ocean. In contrast, the croaker, which also depends on the waters of estuaries for reproduction, spawns at the entrance to the estuary and the young are transported upstream to the plankton-rich, less saline part of the estuary, where they develop before returning to the ocean.

Open ocean fish, such as the bluefish, whose early life histories are totally marine, migrate into estuaries as adults to feed on the abundant food available there.

These varied patterns of estuarine use are concurrent as each species follows its own seasonal and reproductive sequence. Thus an estuary may include the regular or occasional presence of several hundred species of fish. The low-salinity portion of the estuary is of exceptional importance since it receives the eggs, larvae, and young of fish with different kinds of spawning patterns. Although this aspect of the estuary is highly valuable, its value is not obvious because these stages in the life cycle

of fish are not immediately recognizable. Since many large cities are located near estuaries close to the head of navigable waters, this potential impact merits special attention.



MARSHES

Marshes are broad wet areas where grasses grow in abundance. When they are located along the margins of ponds, streams, or rivers, they are freshwater marshes. When they are found on ocean coasts or along the banks or margins of estuaries, they are salt water marshes. Salt water marshes are the nurseries of the sea. They are the most productive land on earth, producing three times more than the best wheat lands.

Biologically, marshes are transitional between wet and dry areas, and they are usually very productive in terms of the biomass they can support. If undisturbed by nature or man, most marshes gradually fill with detritus and are eventually invaded by dry land plants.

In freshwater ecosystems, marshes contain such water-tolerant species as cattails, bullrushes, horsetails, arrowgrass, flowering rushes, buttercups, crowfoot, and many types of grasses. These marshes are also homes for many aquatic insects, amphibia, crayfish, isopods, birds, and aquatic mammals; when they are associated with permanent bodies of water, they may serve as nurseries for young fish. Lake St. Clair (a very wide area in the isthmus connecting Lake Huron with Lake Erie), which has extensive marshy areas built on the silt deposited from Lake Huron, is one of the most productive freshwater fisheries in the world.

Salt water marshes can best be classified by their relation to the land or the ocean. Of all salt marshes, the most maritime (bearing the closest relation to the ocean) are those that develop on relatively open coasts. They are bathed in sea water at almost full strength since the freshwater drainage from land is usually minimal. These marshes are usually rich in algae, including free-living species and tiny forms of the brown algae derived from normal forms that are attached to rocky shores near the marshes.

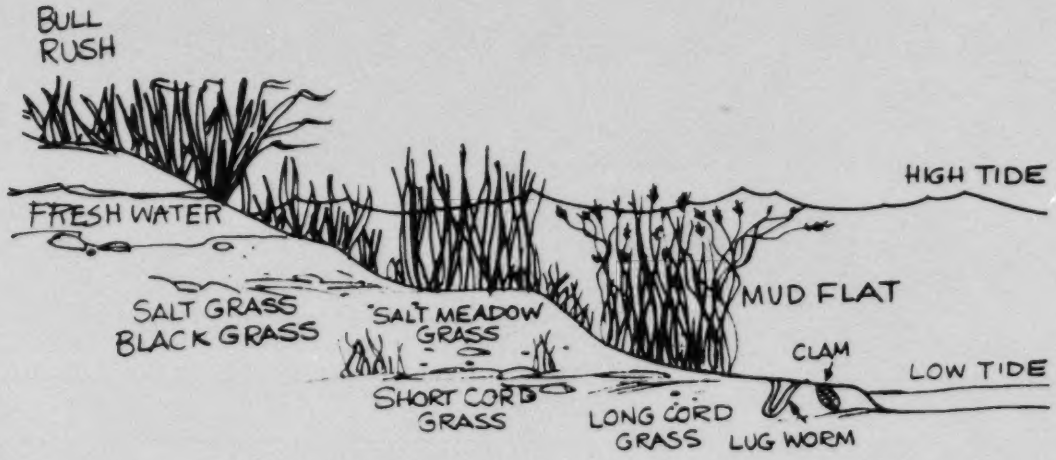
Marshes at the mouths of estuaries, usually found in the lee of coastal spits, are the next most maritime of the salt marshes. The coarse-grained soils of these marshes are subject to stronger saline influence than those of marshes further up the estuary. As their distance from the ocean increases toward the middle and upper reaches of the estuaries, the marshes tend to become progressively more terrestrial since the water becomes progressively fresher.

Despite the wide range of conditions in the United States under which salt marshes exist, some general statements about their formation and the distribution of organisms within them can be made. Salt-marsh formation usually starts in an area that is subject to twice-daily salt water (tidal) inundation. Salt-marshes are replaced by freshwater marshes at

the upper level of tidal influence, where tidal inundations occur only a few times a year. Between these two extremes, plants and animals thrive according to the range of conditions they can tolerate -- conditions that are dominated by the tides the lower levels--and almost independent of them at the upper levels.

Some factors of crucial importance to the survival, growth, and reproduction of organisms in the intertidal zone are the intensity and frequency of mechanical disturbance due to tidal movement; the vertical range over which the tide operates, which determines flooding depths and the vertical extent of the marsh; the form of the tidal cycle, which determines both the frequency and the length of submergence and emergence; and the water quality, which determines, among other things, the amount of light reaching submerged growths and the salinity to which they are subjected.

Grasses are the most prominent plants in salt marshes. Cord grass in a long and a short form, is the grass most likely to live in marsh areas covered by water at high tides. Other salt-tolerant plants and plants tolerant to salt spray make up the upper edges of the marsh and vary with the locality.



A TYPICAL SALT MARSH

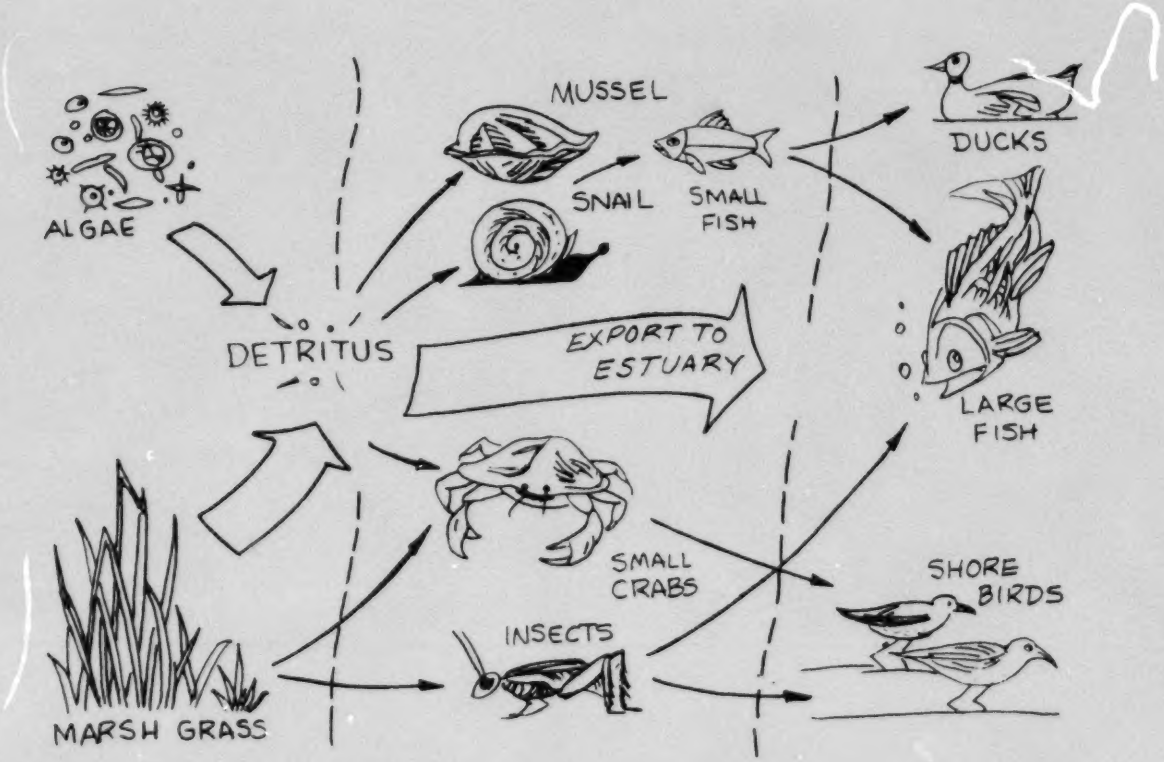
Animals are widely distributed in salt marshes and the adjacent mud flats, although their distribution patterns are not as obvious as those of the plants. Mud flats are occupied by burrowing creatures such as marine worms and clams, which are fed on in turn by other organisms. Fish come in with the tide to feed on the abundant small forms of life that occupy the marshes. Birds are prevalent in marshy areas. Some, such as the marsh wrens, swallows, ducks, geese, herons, and rails nest in or around marshes and get most of their food from them. Mammals such as raccoons, mice, rats and, less often, otters and mink inhabit marshes and feed on other organisms that live there. Marshes are also crucial stopping and feeding stations for flocks of migratory birds.

Marshes are rich in numbers of species as well as numbers of individuals. Species with aquatic larvae, such as mosquitos, gnats, and dragonflies are well represented. Other species, such as grasshopper and cricket, enter the marshes to feed.

In a terrestrial grassland, energy conversion relies on direct consumption of green plants. In contrast, energy conversion in salt marshes relies on decay as the chief link between primary and secondary productivity. Only a small proportion of marsh grass is grazed while it is still alive. Not only is the role of phytoplankton in energy production in marshes less than it is in open water, but also cloudy water or turbidity may diminish algae productivity by reducing the amount of light available for photosynthesis.

The food chain of nature is complex. Each step up the chain involves a a decrease in the number of organisms and an accompanying increase in the amount of food they consume. At the bottom of the food chain, 1000 pounds of phytoplankton will result in 100 pounds of insects and small animals. In turn 100 pounds of insects result in 10 pounds of fish, ducks and birds.

Although it is not shown on this diagram, people are at the top of this steadily narrowing food chain. As in the other steps, it takes 10 pounds of ducks or fish to produce a one pound gain in human beings.



ENERGY CONVERSION IN A SALT MARSH

ACTIVITIES

Coastal Zone Awareness Activities for Elementary School Students

The activities included in this booklet were chosen because they will provide students first-hand experiences with natural phenomena. Such experiences are the basis for learning -- they are thought-provoking and provide ideas to share through speech and writing. Students may even wish to seek out books or other secondary sources of information that will add to their own findings. The purpose of these suggestions is not to have children learn all about coasts but rather to provide an experiential background that will be the basis for a lifelong interest in coastal processes.

When visiting a beach or shore students should be encouraged in positive ways to leave the area in the same shape they found it. When any microhabitat, such as a rock or log, is moved, it should be replaced as it was found. If organisms are living under it they may depend on that object for survival. Children should be helped to understand why they should not collect living things but only observe them.

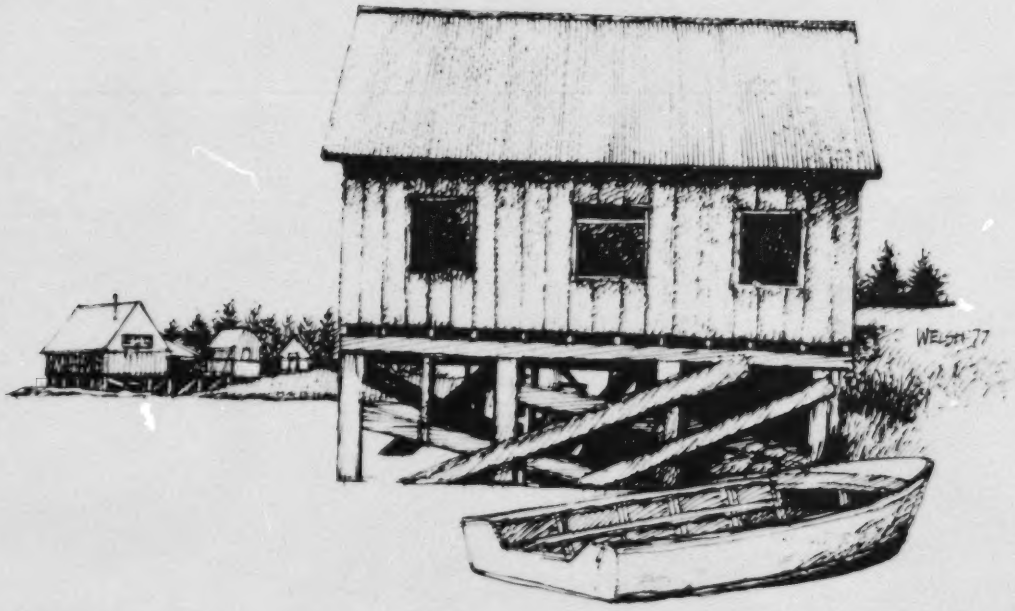
WHAT FLOATS?

Have children collect natural objects along the shore, put them in water, and observe whether they float or sink. They should try as many different kinds of substances as they wish but should also experiment with different shapes of the same substance. The more such experiments each child attempts, the better the experience will be. In a group discussion after the experiments see if the children can develop some generalizations about floating and sinking. Avoid summarizing their experiences for them since this would probably not significantly add to their long-term learning.

Have students who cannot visit the coast collect and bring objects to the classroom and substitute containers of water for the coastline.

FRESH WATER OR SALT?

In the classroom students can discover some of the differences between the properties of fresh and salt water. Some or all of the following manipulations can be included. Compare the level at which different objects float in fresh and salt water and the time it takes them to sink. Place a drop of colored fresh water in a container of fresh water and a drop of colored fresh water in a container of sea water. Observe and discuss the difference in the results.



AT THE BEACH

At the coast, there are many things for children to do.

They should close their eyes and listen to the sounds waves make as they break on the beach. Do they make the same sounds on sandy beaches and rocky beaches? Do the waves sound near or far away?

Have the children describe what sea air smells like. How far away from the beach can they smell it?

They can look for bird footprints in the sand. Are there more tracks near the water's edge or farther up on the beach? Can they guess the size of the bird that made each kind of print? Let the children make a drawing of a bird footprint or help them make plaster casts of bird footprints to take home.

In a class discussion period make a list of the different kinds of birds the children saw at the beach. See if they can remember and mimic the kinds of sounds each one made.

Help the children make a plant collection of the different kinds of water plants they found washed up on the open beach. What is the biggest one they found? The smallest? Where do they think they came from?

Using Tide Tables

People who live near oceans can plan exploratory trips to the sea shore more effectively if they know what the tidal level will be when they get there. If you want to go to see the animals that live at the lower level of the intertidal zone then you should visit the shore when the tides are at their lowest ebb. You can find this information by getting a tide table for your local area. Reading a tide table seems difficult at first so practice on the sample below which was taken from a table constructed for Breakwater Harbor, Delaware. Tide tables give you six kinds of information:

OCTOBER 1970

Month	*Time*		*Year*
Date	16	0236 -0.5	*Height of tide*
Day of Week	TH	0906 5.6	*(2 high tides and*
		1524 -0.4	*2 low tides)*
		2136 4.4	

The time is based on the 24 hr where 0000 is 12 o'clock midnight and 1200 is 12 o'clock noon. So 0236 would be 2:36 AM and 1524 would be 3:24 PM. The height of the tide is related to the mean low water level. A number preceded by a minus sign means that the water level will be below mean low water. No minus sign indicates the height of the water above mean low water.

17	0318	-0.3
SA	0954	5.4
	1612	-0.2
		4.0
18	0406	0.0
SU	1042	5.2
	1706	0.1
	2312	3.7
19	0454	0.3
M	1136	4.9
	1800	0.4
20	0006	3.4
TU	0548	0.6
	1230	4.5
	1900	0.7

Using the information above answer the following questions.

1. What day of the week will have the highest tide?
2. On which date will the high tide be the lowest?
3. Which day would be best for looking for organisms farthest down the beach?
4. Using the 12 hour clock what is the best time to visit the beach on Sunday during high tide?

Have the children try to make a sand castle that the waves can't wash away, using materials from the beach to make it as strong as possible. Ask them to describe what a wave does to the hole they dug in the sand.

Make a "Treasure Chest" of things the children found on the beach. See if they can guess where each kind of treasure came from -- and how? Make a classroom display of the treasures collected at the beach. Invite other classes to view the collection.

Take the class to visit a rocky beach at low tide. Have pieces of shrimp or fish to feed pieces of food to small crabs or anemones and ask the children to describe how they responded. How many other kinds of living things did they see in the tidal pool?

In the classroom have the students put some sand and some soil in a container of water and stir it. Let the sand and soil settle and then ask them to describe which is on top and which on the bottom. Have them do it again and compare the results. Ask them why they think layering occurs.

Take the class on a walk along the edge of a marsh. In the classroom discuss and list the kinds of birds they saw and heard. How does this list compare with the list they made after their visit to the beach?

At low tide, have the children put some mud from a tidal flat on a piece of window screen and wash it gently with water. Have them describe what remains on the screen. Have them look at dock pilings while the tide is still out. How is the part that is covered at high tide

different from the part exposed at low tide? Have them describe any living things they see on the piling.

At low tide make a map of a small section of coastline. Include rocks, curves in the beach, and the location of logs and other things that are lying on the beach. Make another map of the same place at high tide. Compare the maps.

Have the students put a stick in the sand where they think the high tide will just reach it but not wash it away. Watch to see what happens. Can they make a more accurate guess the next time?

In the classroom, put some brine shrimp eggs in fresh water and some in salt water and have the children observe the containers for a few days. Ask them where they think brine shrimp live. Let them use a microscope to observe the brine shrimp when they start to swim.

Take the class on a trip to a local market. How many kinds of coastal organisms are for sale? How many people handled them before they reached the store?

Have the children put a rock in the sand just below where the waves are washing up on the beach. (Do this only if the waves are small and not dangerous.) After each wave goes out have them look at the sand around the rock and describe what is happening.

Have the class observe the groups of small birds that peck the sand just above the wave line. Have them discuss whether the group has a leader, what the birds are pecking at, and how they avoid getting wet.

FURTHER RESOURCES

READING SUGGESTIONS*

ABOUT THE BIGGEST SALMON. Will Hayes, Melmont Publishers, Inc. 1961. Grades 3-4. 32 pages. Fiction.

A factual account of the lifespan of one salmon. Could be used as a reference book.

ABOUT RIVERS. Albert Dickey. Melmont Publishers, Inc. 1959. Grades 3-4. 32 pages. Informational. #105 and #108.

An explanation about where rivers begin and some of their experiences as they flow along. Black-and-white photographs enhance the appeal of this book.

ALL ABOUT THE SEA. Ferdinand C. Lane. Random House. 1953. Grades 5-6. 150 pages. Informational. #102, #106 and #108.

A general exploratory book about marine ecosystem. Tells how the sea began; briefly describes sea life; and concludes with an explanation of man's relationship to sea. Could be used as a listening exercise for lower intermediate children.

ALL KINDS OF SEALS. Bernice Kohn. Random House. 1968. Grades 5-6. 81 pages. Informational.

A descriptive book showing how seals changed from land to sea animals, their environment, and their relationships to man. Could be used as a reference book.

*Adapted from Project COAST, Language Arts Activities to Supplement Coast Learning Experiences (Learning Experience No. 5). One of a series of 86 learning experiences on Coastal and Oceanic Awareness available from Project COAST, 310 Willard Hall, University of Delaware, Newark, Delaware 19711.

(#) Numbers indicate Project COAST Learning Experience with which book may be used.

THE ART AND INDUSTRY OF SANDCASTLES. Jan Adkins. Walker Publishing Co. 1971. Grades 5-8 and all other readers. 29 pages. Informational. #107

Twenty-nine 11" x 15" hard-cover pages. This unique book cleverly combines the popular seaside occupation of sand castle building with the lives and times of ancient castle dwellers. The handsome monochrome illustrations show the sand castle builder and the how and why of castle construction; they help develop a vocabulary and a historical perspective in the process. Thoroughly enjoyable.

THE BEACHCOMBER'S BOOK. Bernice Kohn. The Viking Press. 1970. Grades 4-8. 96 pages. Informational.

For the child who has access to the beach, this book offers suggestions for artistic and scientific activities. How to press seaweeds, how to make beach collages and mobiles are examples. Illustrations are by Arabelle Wheatley. There is an index, a bibliography, and a brief catalogue of Atlantic and Gulf Coast shells.

THE BEACHCOMBER'S HANDBOOK OF SEAFOOD COOKERY. Hugh Zachary. John F. Blair, Publisher. 1969. For all readers. 208 pages. Informational.

More than a cookbook. This is a sincere commentary on seaside conservation. There's a recipe for just about any common marine animal including octopus. The line drawings are decorative. There is a serviceable index.

THE BEAVER POND. Alvin Tresselt. Lothrop, Lee & Shepard Co. 1970. Grades 1-6. 17 pages. Fiction.

Following the construction of a beaver dam, there is a complex and predictable succession of ecological events. This book tells the story of the history of a beaver pond and meadow. There are about 28 illustrations, most of which are in color.

THE BIG BOOK OF REAL BOATS AND SHIPS. George J. Zaffo. Grosset & Dunlap. 1951. Grades 3-6. 25 pages. Informational. #105, #110

Descriptive account of different types of sea-craft. Large pictures help demonstrate different aspects of each craft.

THE BIGGEST HOUSE IN THE WORLD. Leo Lionni. Pantheon Books, Inc. 1968. Grades K-2. 30 pages. Fiction. #101

A story about a snail and his longing for the "biggest house." Large, colorful pictures should enhance the appeal of this book to the youngest readers.

BIRTH OF AN ISLAND. Millicent E. Selsam. Harper and Row Publishers. 1959. Grades K-3. 47 pages. Fiction.

In story fashion the book tells of the birth of an island from an oceanic volcano. Then it describes the natural succession of plants and animals that come to live on the island. Winifred Lubell provided the color illustrations.

THE BLUE WHALE. Kazue Mizumura. Thomas Y. Crowell Co. 1971. Grades 3-4. 34 pages. Informational.

A factual book about whales, especially the blue whale. Includes a message about possible extinction of that animal. Includes pictorial accompaniment to reinforce the facts presented.

A BOOK OF SNAILS. Sally Moffet Kellin. Wm. R. Scott, Inc. 1968. Grades 5-6. 48 pages. Informational.

A reference book about snails includes the snail's life cycle and instructions for keeping them as pets in terrariums. Reference is made to why snails may be considered as pests. Black-and-white photographs help to make this book a good selection for high-interest reluctant readers.

THE BOTTOM OF THE SEA. Augusta Goldin. Thomas Y. Crowell Co. 1966. Grades K-2. 34 pages. Informational.

A descriptive book about the land under the ocean. Canyons, reefs, volcanos and cliffs are among the formations explained in brief terms. Illustrations help to make the definitions understandable to young readers.

BURT DOW: DEEP-WATER MAN. Robert McCloskey. The Viking Press. 1963. Grades K-2. 63 pages. Fiction.

A tall tale about a fisherman who catches a whale by the tail and then bandages it with striped bandage. The events that happen afterward will hold the interest of the reader. Large, colorful pictures make this a book which should be enjoyed by even the youngest students.

CAPTAIN COOK. H. Bellis. McGraw-Hill Book Co. 1968. Grades 5-6. 60 pages. Biography.

A biography about the British explorer, Captain James Cook. Includes details about his voyages. Pencil drawings and maps are used for further explanation.

CAPTAIN COOK: PACIFIC EXPLORER. Ronald Syme. William Morrow & Co. 1960. Grades 3-4. 96 pages. Biography.

A biography about the British explorer, James Cook. Realistically traces his life from his early boyhood to his death. Details of his explorations are woven into a story geared towards 9- or 10-year olds.

CATCH A WHALE BY THE TAIL. Edward R. Ricciuti. Harper & Row Publishers. 1969. Grades K-3. 61 pages. Fiction.

The interesting story of an expedition to catch a companion and mate for a small white whale in an aquarium. The attractive illustrations are cartoons.

CLIMATOLOGY AND WEATHER SERVICES OF THE ST. LAWRENCE SEAWAY AND GREAT LAKES. U.S. Weather Bureau. TECHNICAL PAPER NO. 35. 1959.

THE CRAB FROM YESTERDAY: THE LIFE CYCLE OF A HORSESHOE CRAB. John F. Waters. Frederick Warne and Co., Inc. 1970. Grades K-5. 40 pages. Fiction. #111

The life history and ecology of the horseshoe crab are woven into a fictional account of a small boy's day of beachcombing. Mr. Waters is a very sensitive writer. Illustrations by W. T. Mars also make this a highly commendable book.

CRABS. Herbert and Lucretia Krantz Zim. William Morrow & Co. 1974. For beginners and others. 64, 8" x 11" hard-bound pages. Informational. #101, #102

Quite a thorough and well illustrated manual on common crabs with brief introduction to anatomy, life cycle, behavior, and identification. A one-page index.

CREATURES OF THE DEEP. Agnes McCarthy. Prentice-Hall, Inc. 1963. Grades 5-6. 79 pages. Informational.

A book about various kinds of life in the sea. Some are familiar and all are intriguing. Much information about life in the sea is presented.

DIRECTORY OF SHIPWRECKS OF THE GREAT LAKES. Karl E. Heden. Bruce Humphries Publishers. Boston. 1966.

DOLPHINS! Margaret Davidson. Scholastic Book Services. 1975. Beginning readers. 48 pages. Informational.

Describes the life of dolphins. Illustrated generously in monochrome. Very elementary.

ELISABETH AND THE MARSH MYSTERY. Felice Holman. The Macmillan Co. 1966. Lower Intermediate. 49 pages. Fiction.

A mystery story that offers information as well as intrigue. Elisabeth and a friend try to identify strange calls from the marsh. In doing this they learn about bird migration. The facts in this book do not seem dull because humor is maintained through story-telling.

ELISABETH, THE TREASURE HUNTER. Felice Holman. The Macmillan Co. 1964. Lower Intermediate. 42 pages. Fiction. #102

A story about Elisabeth, Papa, and a friend who are looking for hidden treasure. The person who hid the treasure gave them clues. In trying to follow the clues, they discover life on the shore. The plot of the story overshadows information about marine life in this story.

EXPLORING A BROOK: LIFE IN THE RUNNING WATER. Winifred and Cecil Lubell. Parents Magazine Press. 1975. Lower Intermediate. 61 pages. Informational. #114

A one- or two-page explanation of the various kinds of plant and animal life found in and near a brook. Pencil sketches illustrate each description.

EXPLORING AN OCEAN TIDE POOL. Jeanne Bendick. Garrard Publishing Co. 1976. Grades 2-4. 64 pages. **Informational.** #102

Examines the ecosystem of a tide pool. Discusses tides, tidal zones, the formation of tide pools, the plants and animals found in a tide pool, and the effects of pollution on a tide pool and the ocean. Both color and black-and-white photographs included.

EXPLORING AND UNDERSTANDING OCEANOGRAPHY. Anabel Dean. Benefic Press. 1970. Lower and Upper Intermediate. 96 pages. Informational.

A question-and-answer format is used to explain the fundamentals of oceanography. It begins with a description of the planet Earth; tells about currents, waves, and tides; and concludes with a discussion of underwater exploration and treasures from the sea. Each chapter concludes with questions and simple experiments. A resource book that would be of value for a learning experience about oceanography.

FAMOUS SMALL BOAT VOYAGES. Walter Buehr. G. P. Putnam's Sons. 1966. Grades 4-6. 128 pages. Informational. #110

Discusses the preparations and adventures of the crews of nine small boats on long and hazardous voyages. Included are tales of the first Atlantic crossing by a lone woman, the first Atlantic crossing in a rowboat, and the first single-handed cruise around the world. Illustrated with two-color sketches.

FINS AND TAILS: A STORY OF STRANGE FISH. Elizabeth A. Campbell. Little, Brown & Co. 1963. Lower Intermediate. 58 pages. Informational.

A story about different kinds of fish found in the oceans. Using analogies (e.g., swimming balloon for puffer), the author describes some varieties of strange fish in simple sentences. Pictures accompany each description.

FISHES. Brian Wildsmith. Franklin Watts, Inc. 1968. Primary. 34 pages. Informational.

A picture book about names given to different groups of fish. Illustrated in shimmering colors. Geared to the primary student but holds aesthetic enchantment for lower intermediate groups.

FISHES. Loren P. Woods. Follett Publishing Co. 1969. Grades 3-6. 32 pages. Informational.

This excellent book on fishes discusses their evolution, distribution, and ecology. The book is enhanced by Tom Dolan's brilliant color illustrations. The sections on coral reef fishes, deep-sea fishes, and fishes of the West Indies are particularly well done.

FISHES. Herbert S. Zim and Hurst H. Shoemaker. The Golden Press. 1955. Middle School and others. 160 pages. Informational.

For the identification of the common fresh and salt water fishes of North America. Species are identified by color pictures. Common and scientific names are given. Useful guide for beginners.

FISHES OF THE GREAT LAKES REGION. Carl Hubbs and Karl Lagler. Bulletin 26 (rev.). Bloomfield Hills, Michigan. Cranbrook Institute of Science, 1958.

FISHING FOR TUNA. Lewis Allison. Melmont Publishers, Inc. 1957. Lower Middle School. 35 pages. Informational. #104, #105

The ships, nets, and procedure of catching tuna are well described. Good monochrome illustrations of tuna and tuna fishing.

FISH IS FISH. Leo Lionni. Pantheon Books, Inc. 1970. Grades K-2. Fiction.

An enchanting story about the way a fish imagines the outside world as described to him by a worldly frog who's seen it. Beautiful illustrations.

THE FLYING LESSONS OF GERALD PELICAN. Nathaniel Benchley. Harper & Row Publishers. 1970. Grades K-3. 32 pages. Fiction.

Clever dialogue as seaside animals attempt to deal with the predicament of a rash young pelican. Each friendly bird has its own advice on how to fly and there's a happy ending. Attractive drawings.

FRESHWATER FURY YARNS AND REMINISCENCES OF THE GREATEST STORM IN INLAND NAVIGATION. Frank Barcus. Wayne State University Press, Detroit. 1960.

THE FRIENDLY DOLPHINS. Patricia Lauber. Random House. 1963. Grades 4-6. 79 pages. Informational.

Many different aspects of the dolphin are covered: the history of the dolphin as a friend of man; its physical make-up and similarities to other species; and its unique sonar talents. Photographs and sketches are included.

FROGS MERRY. Juliet Kepes. Pinwheel Books. 1973. Grade K-1. Fiction.

A light-hearted story that discusses the interactions of species in a pond. Adorable blue, green and black illustrations provide a pond atmosphere.

THE GREAT LAKES READER. Walter Havighurst. New York, New York. The Macmillan Company. 1966.

GEOLOGY OF THE GREAT LAKES. Jack L. Hough. Urbana, Illinois. University of Illinois Press. 1958.

THE GLACIAL LAKES SURROUNDING MICHIGAN. Robert W. Kelly. Lansing, Michigan. Michigan Department of Conservation. December 1960.

GREAT LAKES COUNTRY. Russell McKee. New York, New York. Thomas Y. Crowell Co. 1966.

GREAT SEA POETRY. Willard Bascom, ed. Compass Publications, Inc. 1969. Upper Middle-High School. 119 pages. Poetry.

Includes poems by Rudyard Kipling, A. A. Milne, John Masefield, Lewis Carroll, Matthew Arnold, Robert Browning, Oliver Wendell Holmes, Sir William Gilbert, John Gray, and J. Frank Stimson. The poetic nature of the sea becomes evident as one reads the descriptive emotion-filled lines. A glossary of special words and a gazetteer of places (listed by poem) is included.

GREAT STEAMBOAT MYSTERY. Richard Scarry. Random House. 1975. Grades K-2. Fiction.

Mr. and Mrs. Pig staged a party on a steamboat and hired two detectives to protect the wedding gifts. Nevertheless, there's a theft and quite a mystery until the clever detectives bring the story to a happy ending. Attractive cartoon illustrations.

THE GREAT WHALES. Herbert S. Zim. William Morrow & Co. 1951. Grades 3-6. Informational. #204

An extremely detailed description of the physiology of the whale. Different species and habits of whales are discussed and depicted by black-and-white drawings. Large print would probably make this book appealing to young whale enthusiasts.

GULLS. Sarel Eimerl. Simon and Schuster. 1969. Grades 4-8. 64 pages. Informational. #202

Nature writer Sarel Eimerl describes various members of the gull family, their feeding and hunting habits, and their migratory and courtship behavior. Illustrated with 30 black-and-white photographs. Index included.

HARVESTING THE SEA. D. X. Fenten. J. B. Lippincott Co. 1970. Grades 4 and up. 58 pages. Informational. #3, #201, #209

A good reference for learning about the riches found in the sea (plants, animals, and minerals) and careers related to the harvesting of these riches. Photographs and sketches are good.

HARVEY'S HIDEOUT. Russell Hoban. Scholastic Book Services. 1972. Grades K-3. Fiction. #108

The story of a rivalry between a brother and sister muskrat who soon realize they are lonely and need each other. Good for children with brothers and sisters. Cute brown illustrations.

HIGH WATER AT CATFISH BEND. Ben Lucien Burman. Puffin Books. 1974. Grades 4 and up. 123 pages. Fiction.

Enchanting story of five animals who realize they must forget their personal problems and work together. Their home is the Mississippi flood plains and they are disgusted with the way humans are controlling floods. They unite to do something about it.

HORSESHOE CRAB. Robert M. McClung. William Morrow & Co. 1967. Lower Intermediate. 48 pages. Fiction. #101, #102, #103, #111

Describes the life cycle of the horseshoe crab, an animal that is a common sight along the Atlantic coastline. Also describes the parts of the horseshoe crab one can observe at the beach. Black-and-white sketches illustrate and add much detail to the text.

HOUSES FROM THE SEA. Alice E. Goudey. Charles Scribner's Sons. 1959. Primary. 32 pages. Fiction. #101, #102, #103, #106, #109

The story of two children who spend a day on the beach collecting shells. Common names of the shells are given in the story. A section at the end of the book shows shells and their names. Author has included two pages explaining how shells are formed. Teacher would read this section to the group. Accurate and imaginative pictures in delicate colors are included.

THE HOW AND WHY WONDER BOOK OF SEA SHELLS. Donald F. Low. Grosset & Dunlap. 1974. Grades 3-6. 48 pages. Informational. #102

A good research book that simply and factually answers just about any questions a youngster might have about shells.

IN THE DEEP BLUE SEA. Elizabeth Morgan. Prentice-Hall, Inc. 1962. Upper Intermediate-Middle School. 70 pages. Informational.

An account of the sea--its explorations, ocean mining, oil-drilling, harvesting of ocean crops, and fossils of the deep. The book also includes simple explanations of some jobs which can be found involving working under the sea. A beginning study of oceanography. Acquaints reader with the past and present research, underwater archaeology, biology, and the importance of the sea for the future.

ISLAND OF THE BLUE DOLPHINS. Scott O'Dell. Houghton Mifflin Co. 1960. Grades 6 and up. 184 pages. Historical Fiction.

An account of a young native girl's life alone on the "Island of the Blue Dolphins." This fascinating tale is based on facts recorded by ship captains that actually knew the girl. A must for adventure lovers.

JOHN TABOR'S RIDE. Blair Lent. Atlantic Monthly Press. 1966. Lower Intermediate. 48 pages. Fiction.

A tall tale about a shipwrecked man named John Tabor who hitches a ride on a whale from the South Seas to his home in Nantucket. He has a traveling companion and together they havean encounter with Neptune. Detailed illustrations add interest to the story.

JUNIOR SCIENCE BOOK OF SEA SHELLS. Sam and Beryl Epstein. Garrard Publishing Co. 1963. Primary. 62 pages. Informational. #102

A very elementary introduction to mollusks including some without external shells (squid). An effort is made to classify and show geographical distribution of the shells. Includes an index and black-and-white illustrations.

KERMIT THE HERMIT. Bill Peet. Houghton Mifflin Co. 1965. Primary and Lower Intermediate. 48 pages. #102, #103, #106 Fiction.

A story, told in rhyme, about a selfish crab who is a hermit. An act of kindness by a young boy and its effect on the crab convey the message of this book. The drawings that accompany the story add a lot of detail to the text. A good book to read aloud to children.

LAKE ERIE. Harlan Hatcher. Bobbs Merrill Company.

LAKE HURON. Fred Landon. Bobbs Merrill Company.

LAKE MICHIGAN. Milo M. Quaife. Bobbs Merrill Company.

LAKE ONTARIO. Arthur Pond. Bobbs Merrill Company.

LAKE SUPERIOR. Grace Lee Nute. Bobbs Merrill Company.

LANDS ADRIFT: THE STORY OF CONTINENTAL DRIFT. Malcolm Weiss. Parents Magazine Press. 1975. Grades 4-6. 63 pages. Informational.

A readable and enjoyable discussion of how land has drifted and changed over million of years. Also presents historical hypotheses of how this occurs.

THE LAST FREE BIRD. Harris A. Stone. Prentice-Hall, Inc. 1967. All grades. Fiction. #104

A plea to save our environment is made in this picture book for all ages. Beautiful water color illustrations.

LET'S EXPLORE A TIDE POOL. Bruce E. Tatje and Mark A. Weise. Science Dept., Martin County High School, Stuart, FL. 1971. Grades 2 and up. 39 pages. Informational. #102

A clear, concise guidebook for exploring a tide pool. The environment and the organisms found in it are described and often sketched. An asset to a group of young marine biologists.

LET'S FIND OUT ABOUT THE OCEANS. David C. Knight. Franklin Watts, Inc. 1970. Grades 3-5. 59 pages. Informational.

The size, names, tides, and living things of the oceans are discussed in this book. Some of the concepts may be difficult for young readers. Also, there are only two pages dealing with plants. Simplified black-and-white illustrations.

LET'S GO ON A TURTLE WATCH. Diana Hart and Larry Crary. Martin County High School, Stuart, FL. 1970. Grades 3 and up. #114 Informational.

A well presented field guide for young children interested in turtles and their habitats. Bibliography included.

LET'S GO TO THE BEACH. Ken Walker, et al. Hurricane House Publishers, Inc. 1969. Grades 3 and up. Informational. #102

A simple but highly informative guide to Florida beach ecology. Designed for use while observing marine life. Simple black-and-white illustrations are intended to be colored accurately by observers.

THE LITTLE ISLAND. Golden MacDonald. Doubleday & Co. 1946. Grades K-4. 40 pages. Fiction.

The ecology of an island is taught using simple prose and full-page watercolors. An important lesson is that the island is part of the nearby land. This book won the 1947 Caldecott Medal for the most distinguished picture book for children.

LOBSTERMAN. Dahlov Ipcar. Alfred A. Knopf, Inc. 1962. Grades 4 and up. 38 pages. Fiction.

Color paintings profusely illustrate the work of the lobsterman, his clothing, his boat, the traps, and the lobsters. A boy helps prepare the boat and equipment and finally enjoys a lobster dinner.

LOG TRANSPORTATION IN THE LAKE STATES. W. G. Rector. Glendale, California. A. H. Clark Company. 1953.

THE LONG SHIPS PASSING. Walter Havighurst. New York, New York. The Macmillan Company. 1942.

THE LONG VOYAGE. THE LIFE CYCLE OF A GREEN TURTLE. Alvin and Virginia Silverstein. Frederick Warne & Co. 1972. Middle School and others. 48 pages. Fiction.

The life cycle of the green sea turtle is traced by a team of scientists and a young boy on a long, hazardous journey across hundreds of miles of open ocean. A glimmer of insight into marine research and the balance of nature may be achieved.

LORE OF THE LAKES. Dana Thomas Bowen. Cleveland, Ohio. The Lakeside Printing Company. 1948.

MAGIC OF THE SEA. Max Albert Wyss. The Viking Press. 1968. All ages. 86 pages. Informational.

Superb photographs of the sea and its inhabitants are combined with essay and poems to make a moving essay about people and the sea. The influence of the oceans on human cultures is impressively developed. A handsome book.

LET'S GO TO THE SEASHORE. Harriet E. Huntington. Doubleday & Co. 1941. Grades K-4. 89 pages. Informational. #102

Pictures what a child might encounter during a walk along the seashore. Even-numbered pages bear photographs of marine animals. Odd-numbered pages contain reading material describing the animals in the photographs. This book is included in the American Library Association's list of 1,000 basic books for elementary school libraries.

LET'S LOOK AT SEASHELLS. Phyllis J. Perry. T. S. Denison & Co., Inc. 1971. Grades K-2. 32 pages. Informational. #101

Beautiful watercolor illustrations and clear concise text help the young child learn about the various types of shells found on the beach.

LIFE IN A POND. Carmelita Kipple Robinson, et al. Golden Press. 1967. Primary. 28 pages. Informational. #114

Presents the living things of a pond with labels and a few words of text. Only two pages on plants. The animals represented include common fishes, frogs and toads and their life cycles, snakes, turtles, salamanders, snails, crayfish, insects, and birds. Attractively hard-bound.

LIFE IN THE SEA. Gwynne Vevers. McGraw-Hill Book Co. 1965. Lower and Upper Intermediate. 42 pages. Informational. #102

An informative, handsomely illustrated book about forms of sea life. The author attempts to impart understanding of what the sea is like and how it is explored.

THE LIFE OF SEA ISLANDS. N. J. and Michael Berrill. McGraw-Hill Book Co. 1969. Grades 3 and up. 231 pages. Informational.

A very complete reference that discusses many islands and their origins, wildlife, and importance. Outstanding photographs and illustrations. A top-notch reference.

A MAP IS A PICTURE. Barbara Rinkoff. Thomas Y. Crowell Co. 1965. Upper Elementary School and others. 35 pages. Informational.

Various kinds of maps and charts and their symbols are introduced. This brief experience could lead to many educational experiences.

MARSHES AND MARSH LIFE. Arnold Dobrin. Coward-McCann. 1969. Grades 4-8. 47 pages. Informational.

The author successfully describes marsh life in terms of the effects that seasonal changes and tidal fluctuations have on the marsh's inhabitants. The well written book is illustrated with the author's brilliant watercolors. A strong case is made for marsh conservation.

MEET THE MEN WHO SAILED THE SEA. John Dyment. Random House. 1966. Lower Middle School. 85 pages. **Informational.** #110

A historical treatment of sailing craft and sailors from log canoes and reed boats to clipper ships. It ends with a brief account of Slocum's solo voyage around the world in 1895. Famous mariners included Eric the Red, Marco Polo, Magellan, Cook, and Francis Drake. Nicely illustrated with monochrome drawings.

MISS PICKERELL GOES UNDERSEA. Ellen MacGregor. McGraw-Hill Book Co. 1953. Grades 4-8. 125 pages. Fiction.

What a fun way to learn about sonar, atomic-powered submarines, and under-the-sea salvaging. The always unpredictable Miss Pickerell must use these things in the recovery of her priceless Mars rocks that were being transported on a ship that sank.

MOON JELLY SWIMS THROUGH THE SEA. Marie M. Jenkin. Holiday House. 1969. Grades K-4. 48 pages. Fiction. #102

This book provides a useful service to children's literature in that it supplies authentic information about the life cycles of jellyfishes without personifying them. The colorful illustrations are by Rene Martin.

MY SEA. Hermann Fay. Hubbard Press. 1974. Grades K-1. ABC book. Informational.

An excellent book to reinforce the alphabet for a child interested in the sea. Beautifully detailed illustrations. But words beginning with h, i, j, l, n, q, r, u, v, x, y, and z are not included. Probably intended as a reference book by the author. Individual pictures are labeled with capitals and lower case letters in the words. Drawings are the book's strongest feature.

NETS OVERBOARD! Jack Coggins. Dodd, Mead & Co. 1965. Grades 6 and up. 96 pages. Informational.

An account of the methods used in the fishing industry. Oceanography and life in the sea are also discussed. Many supporting pictures and captions.

NINE TRUE DOLPHIN STORIES. Margaret Davidson. Scholastic Book Services. 1974. Grades 3-6. 64 pages. Informational.

Nine amazing stories about dolphins--most in natural habitats, some in man-made surroundings. Pleasant reading. The few illustrations are cartoon-like.

NORTH, SOUTH, EAST, AND WEST. Franklyn M. Branley. Thomas Y. Crowell Co. 1966. Grades 3 and up. Informational. #105

The useful skill of knowing how to determine directions is dealt with here. Shadows, compasses, and maps are used to help determine north, south, east, and west. Simple, clear illustrations.

OCTOPUS LIVES IN THE OCEAN. William and Peggy Stephens. Holiday House. 1968. Middle School. 47 pages. Fiction.

Does a good job of describing the life of an Atlantic octopus for young readers. The book is well illustrated mostly in black-and-white, and the common neighbors of the octopus are introduced in interesting accounts of day-to-day events.

PADDLE-TO-THE-SEA Holling Clancy Holling. Houghton Mifflin Co. 1941. Grades 3-5. Fiction. #110

An excellent book for learning about the flow of water from the snow on a mountaintop to salt water in the ocean. A young Indian boy carves an Indian in a canoe that he places in the snow on a mountain near the Great Lakes. The book traces its voyage to the Atlantic Ocean. Wonderful illustrations.

PAGOO. Holling Clancy Holling. Houghton Mifflin Co. 1957. Grades 3-9. 87 pages. Fiction. #102,

This book tells the story of Pagoo, a hermit crab, from larvation to maturity. Life in the tidal pool is not easy. There is a chronic housing shortage. Risks are incurred in the love-making adventures. This complete book has 20 full-page color drawings and numerous marginal illustrations.

PEA PATCH ISLAND. Polly Curran and Ronald Himler. Western Publishing Co. 1975. Beginning readers. 32 pages. Historical Fiction.

Tells a legend of how Pea Patch Island in the Delaware River got its name. Very attractive color illustrations with a very simple text. A pleasant story that could lead to other interesting assignments, at least for Delawareans.

THE PENGUINS ARE COMING! R. L. Penney. Harper & Row Publishers. 1969. Grades K-4. 63 pages. Informational.

R. L. Penney, a research zoologist at the Bronx Zoo, tells what he learned about Adelie penguins on five trips to Antarctica. The book contains detailed and accurate information for the beginning reader. The 35 drawings by artist Tom Eaton are bold and imaginative.

PENGUINS, OF ALL PEOPLE! Don Freeman. The Viking Press. 1971. Grades 3-4. 30 pages. Fiction.

Color illustrations with a few words of text telling the story of ambassador penguins visiting the United Nations as delegates. Scenes of the Antarctic and New York City lead to the U.N. General Assembly where the penguins advise the human delegates to solve their problems as penguins do by "working, playing, and having fun together."

PIONEERS OF EARLY WATERWAYS. Edith McCall. Childrens Press. 1961. Middle School. 127 pages. Biography.

A collection of stories about early Americans on the canals and rivers. Includes stories about Davy Crockett, Mike Fink, and Mark Twain. A steamboat race is the climax.

POLAR BEAR. Kay McDearmon. Dodd, Mead & Co. 1976. Grades 1-4. 46 pages. Fiction.

Describes the life cycle, life-style, and habitat of the polar bear. Illustrated with black-and-white photographs.

THE POND. Donald and Carol Carrick. The Macmillan Co. 1970. Grades K-2. 33 pages. Informational. #114

Contains little science, but the watercolors by artist Donald Carrick are good. They portray pond life in the style of oriental silk screens. The text by Carol Carrick is poetic, but too brief.

POND LIFE: A GUIDE TO COMMON PLANTS AND ANIMALS OF NORTH AMERICAN PONDS AND LAKES. George K. Reid. Golden Press. 1967. Middle School and others. 160 pages. #114 Informational.

Mostly a very usable manual for identification of a wide variety of common plants and animals of fresh water ponds, including birds and mammals. There is a very brief treatment of the physical features of a pond and of aquatic ecosystems, and a bibliography and five-page index. Useful for amateur pond watchers of all ages.

QUESTIONS ABOUT THE OCEANS. Harold Dubach and Robert Taber. U.S. Government Printing Office. Grades 3 and up. 121 pages. Informational.

Look up the question you want answered in the table of contents, turn to the page on which that question appears, and there you have it. One hundred questions are answered. Relevant diagrams and sketches are included. Simple, easy-to-use reference book.

QUESTIONS AND ANSWERS ABOUT SEASHORE LIFE. Ilka Katharine List. Four Winds Press. 1970. Upper Intermediate. 123 pages. Informational. #102

Excellent book. Uses a question-and-answer format to discuss the animals found near rocky, sandy, and muddy shores. Well illustrated.

THE QUEST OF CAPTAIN COOK. Millicent E. Selsam. Doubleday & Co. 1962. Grades 6 and up. 126 pages. Informational.

James Cook's efforts to explore uncharted oceans and lands come to life in this book. His travels took him around the world and resulted in the discovery of many new lands. Simple, yet effective illustrations.

THE RAINBOW BOOK OF NATURE. Donald Culross Peattie. Collins, William & World Publishing Co., Inc. 1957. Grades 3-6. 319 pages. Informational.

This lengthy resource book includes many different aspects of nature: ecosystems; plants and their unique characteristics; animals and their unique characteristics; the effects of temperature and surroundings on plants and animals; and the interactions between species. Factual text and life-like illustrations.

RED FOX AND HIS CANOE. Nathaniel Benchley. Scholastic Book Services. 1973. Grades K-2. 64 pages. Fiction.

A young Indian boy, Red Fox, wants the largest canoe in the world. Who would have guessed all the animals along the river would want to take a ride--all at the same time?

THE ROPE'S END. Reginald B. Hegarty. Houghton Mifflin Co. 1965. Grades 5 and up. 131 pages. Fiction. #110

At the age of 12, Hegarty made his first whaling voyage as a part of the crew on his father's ship. Life on a sailing vessel is not easy for such a mischievous boy. Amusingly, his actions frequently result in a meeting of the seat of his pants with a "rope's end." Exciting, charming, convincing.

SANDPIPERS. Edith Thacher Hurd. Thomas Y. Crowell Co. 1961. Grades K-2. Informational. #102

Simple but descriptive words make this "Let's Read and Find Out Science Book" a pleasure. The child will surely come away with a clearer understanding of the sandpiper.

SCIENCE ON THE SHORE AND BANKS. Elizabeth K. Cooper. Harcourt, Brace & World, Inc. 1960. Informational.

Useful guide for observing, gathering, and studying various forms of plant and animal wildlife in shallow fresh and salt waters.

SEA AND SHORE. Clarence J. Hylander. The Macmillan Co. 1950. Upper Intermediate-Middle School. 242 pages. Informational.

Very readable story of plants and animals that live on the shore. Seaweeds, mollusks, crustaceans, jellyfish, univalves, starfish, sand dollars, and sea urchins are among the forms of life described. The physical features of the ocean environment and how the organisms have adapted are also discussed. Illustrated with black-and-white photographs and diagrams.

SEA CAREERS. D. X. Fenten. J. B. Lippincott Co. 1970. Grade 4 and up. 162 pages. Informational.

An extensive listing of jobs related to the sea. Descriptions, qualifications, schooling, suggested salaries (now outdated), addresses of some sources for information and applications, and an index are included.

SEAHORSES. Lilo Hess. Charles Scribner's Sons. 1966. Lower Intermediate. 46 pages. Informational. #102

This book is about the life cycle of the sea horse. The physiology of the animal is discussed as well as others of its family in the marine environment. Directions for making an aquarium for sea horses are given. Black-and-white photographs are used throughout the book.

THE SEA SEARCHERS: MEN AND MACHINES AT THE BOTTOM OF THE SEA. Terry Shannon and Charles Payzant. Golden Gate Junior Books. 1968. Grades 3 and up. 93 pages. Informational.

A well organized book about the various machines used in exploring and working under the sea. Excellent photographs support the text. Very informative captions make the book easy to pick up and enjoy.

SEASHELLS IN ACTION. Audrey Newell. Walker Publishing Co. 1973. Grades K-4. 38 pages. Informational.

Describes twenty-five animals with shells including oysters, clams, scallops, conchs, and whelks. Includes paragraphs about the squid and the octopus. Illustrated with water-colors. A shell identification chart for teacher reference is included in the back.

SEASHORES: A GUIDE TO ANIMALS AND PLANTS ALONG THE BEACHES. Herbert S. Zim and Lester Ingle. Golden Press. 1955. Grades 5-12. 160 pages. Informational. #102, #107

About 460 forms of seashore life are described and illustrated in this book. It is attractive and authoritative. Its convenient hip-pocket size makes it a useful companion for anyone who frequents the beaches. There is an index with a list of scientific names of the plants and animals discussed.

SEASHORE STORY. Taro Yashima. The Viking Press. 1967. Primary. 18 pages. Fiction. #102, #107

A legendary story about a Japanese fisherman who rides away on a turtle's back and lives for many, many years. This tale is being told to a group of ballet students who are camping at the seashore. Their questions about the tale are told to the reader also. Pastel drawings illustrate this book.

THE SECRET THREE. Mildred Myrick. Harper & Row Publishers. 1963. Primary. 64 pages. Fiction. #107

A story about three boys at the beach who form a club with secret signals, coded messages, passwords, and a meeting place. They have a campout on a beach island and explore dunes, shells, grasses, etc.

SEE ALONG THE SHORE. Millicent Selsam. Harper & Row Publishers. 1961. Lower Intermediate. Informational.
#102 #107

Discusses some of the things children might wonder about as they walk along the beach: why the sea is salty; the formation of sand and dunes; sea shells and animals on the beach; tides and what causes them; and animal tracks in the sand. Also discusses the intertidal zone and insects found near the shore. Colorful illustrations show what is being described.

SEE THROUGH THE LAKE. Millicent Selsam. Harper & Row Publishers. 1958. Lower Intermediate. 48 pages. Informational.

An explanation of lakes--how they were formed, what types of life they support, and the effect of the land around them. A description of specific types of life found at different levels of water is included. Pictures showing clearly what the author is discussing aid in understanding for the young reader.

SEE THROUGH THE SEA. Millicent Selsam and Betty Morrow. Harper & Row Publishers. 1955. Lower Intermediate.

A story about a journey into the depths of the sea and what things a person might see there. Animal and plant life at different depths are explored. The author uses a round insert diagram on every page to help show exactly what part of the sea is being explained.

SHIPS THAT NEVER DIE. Marine Historical Society of Detroit. Detroit, Michigan. 1952.

SHIPWRECKS OF THE LAKES. Dana Thomas Bowen. Cleveland, Ohio. The Lakeside Publishing Company. 1952.

SHRIMPS. Judy Hawes. Thomas Y. Crowell Co. 1966. Primary. 35 pages. Informational.

An informational book about the life cycle of shrimps. The author tells about their habits and how they grow. The reader would also find out about shrimps' long ocean voyages and what part this plays in their life cycle. A watercolor effect is used to illustrate this book.

"SOME SEA TERMS IN LAND SPEECH". Samuel F. Batchelder. The New England Quarterly (January-October). 1929. pp. 625-653.

A delightful compendium of nautical terms in the U.S. language.

STARFISH. Edith Thacher Hurd. Thomas Y. Crowell Co. 1965. 35 pages. Informational. #102

A delightful introduction to the starfish. Its life-style and beauty are described with carefully chosen words. Fascinating illustrations give the reader a feeling of being near the sea.

STRANGE FISHES OF THE SEA. Olive L. Earle. William Morrow & Co. 1968. Lower Intermediate. 63 pages. Informational.

An informational book about some creatures who live in the sea and who are thought to have strange shapes and habits. Compares sea and land animals, such as sea snakes and land snakes. Black-and-white pencil drawings illustrate this book.

THE SUNLIT SEA. Augusta Goldin. Thomas Y. Crowell Co. Lower Intermediate. 33 pages. Informational.

An introductory book about the ecosystem of the undersea world as far down as sunlight penetrates (about 200 feet). Plant and animal life found at this level are described. Drawings done in three colors illustrate this book.

SWIMMY. Leo Lionni. Pantheon Books. 1968. Primary. Fiction.

A picture book about a little fish who is left all alone after his family was eaten by a tuna. His adventures and his struggles to cope with the big fish after he meets a new "family" are the center of this story. Watercolors, used to produce a shimmering underwater effect, are used to illustrate this book.

TARO AND THE SEA TURTLES. Arnold Dobrin. Coward, McCann & Geoghegan. 1966. Lower Intermediate. Fiction.

A Japanese tale about a young boy who dreams of buying gold to gild the Buddha in the village. The realization of his dreams and his adventure to the island to purchase the gold are the focus of the story. Taro's kindness to the sea turtles is reciprocated in an exciting way. Illustrated with black-and-white drawings.

THREE BOYS AND A LIGHTHOUSE. Nan Hayden Agle and Ellen Wilson. Charles Scribner's Sons. 1951. Lower Middle School. 100 pages. #105, #110 Fiction.

A good story with a few black-and-white illustrations about the adventures of three boys who spend a summer helping to tend a lighthouse.

TIM TO THE RESCUE. Edward Adrizzone. Henry Z. Walck, Inc. 1949. Lower Intermediate. Fiction. #105, #110

A story about three boys who are part of the crew of a ship. Tim and Ginger develop a friendship and begin many adventures on the ship. Ginger's problems with his hair, and a hurricane are the major problems. Watercolor drawings illustrate this book.

TO THE BRINK OF EXTINCTION. Edward R. Ricciuti. Harper & Row Publishers. 1974. Grades 6 and up. 169 pages. Informational.

The stories of seven animals threatened with extinction are told: the Puerto Rican Parrot, the shaggy European Bison, Pere David's Deer, the Pine Barrens Tree Frog, the Bog Turtle, the Osprey, and the Gray Whale. The complexities and morality of saving living things from extinction are discussed. There is an index and very short bibliography. The illustrations are poor.

THE TRUE BOOK OF OCEANS. Katharine Carter. Childrens Press. 1958. Primary. 46 pages. Informational. #105

An explanation about the oceans and their floors, surfaces, shores, tides, and currents. Includes a brief description of the plants and animals found in the oceans. Concludes with discussion of ways oceans help people.

THE TRUE BOOK OF PEBBLES AND SHELLS. Illa Podendorf. Childrens Press. 1954. Primary. 47 pages. Informational. #102

An explanation, with accompanying pictures, of how some of the pebbles and shells that might be found on a beach came to be there. The author identifies for the young reader what the shells look like.

THE TRUE BOOK OF SHIPS AND SEAPORTS. Katharine Carter. Childrens Press. 1963. Primary. 47 pages. Informational. #105, #110

A general descriptive book about different kinds of ships. A brief history of ships and their importance is given. The author closes with a chapter about different kinds of seaports and ways in which people depend on them.

THE TRUE BOOK OF TROPICAL FISHES. Ray Broekel. Childrens Press. 1963. Primary. 47 pages. Informational.

A book about tropical fishes, where they come from, and how they are caught and shipped to the United States. An explanation is then given about certain species that could be used in an aquarium. Pictures of types of equipment that could be used in an acquarium are included.

THE TRUE BOOK OF WHALES AND OTHER SEA MAMMALS. Elsa Posell. Childrens Press. 1963. Beginner readers. 47 pages. Informational.

This book is mainly about whales, but discusses walruses, seals, sea cows, porpoises, and sea lions. Mentions the need for control of the whaling industry. Illustrated with drawings.

THE TRUE STORY OF SIR FRANCIS DRAKE, PRIVATEER. Will Holwood. Childrens Press. 1964. Grades 5-6. 138 pages. Biography.

Tells the exciting adventures of the famous English privateer in his many encounters with the Spanish Navy in the sixteenth century. Good reading. Sparsely illustrated. No bibliography, but a two-page index.

UNDERWATER ZOOS. Millicent E. Selsam. William Morrow 1961. Grades 5 and up. 96 pages. Informational.

The building and maintenance of fresh and salt water aquariums are discussed in this book. Appropriate animals, plants, and water conditions are clearly cited for those who would like to begin their own underwater zoos. Simple drawings support the text.

WEATHER OR NOT. Wallene T. Dockery. Abingdon Press. 1976. Grades 4 and others. 32 pages. Fiction.

Young people visit a weather station and are introduced to the basic principles of meteorology and how a weather forecast is made. Fictionalized format contains a lot of information.

THE WHITE PALACE. Mary O'Neill. Thomas Y. Crowell Co. 1966. Lower Intermediate. 48 pages. Fiction (poetic story).

This is an animal fiction story that conveys information to the reader. It is the story of the life cycle of a Chinook salmon. His life begins and he moves into the "white palace." A plot develops and the author's description of the fish's behavior and habitat are credible. Wash drawing illustrations are used in this book.

WONDERS OF AN OCEANARIUM. Lou Jacobs, Jr. Golden Gate Junior Books. 1965. Middle School. 80 pages. Informational. #102

Discusses the life forms commonly found in large aquaria for public viewing and/or research. Well illustrated with black-and-white photographs. Close-ups of fish, octopi, turtles, seals, walruses, whales, otters, and dolphins are shown.

WORLD BENEATH THE OCEANS. T. F. Gaskell. Natural History Press. 1964. Middle School. Informational.

A reference book about man's adventures with the oceans of the world as they have developed from early times until the time of the book's publication. The floors of the oceans are described as are the movements of the water. Plant and animal life found in the deep are also described. Illustrated with drawings and photographs.

YOU AND THE OCEANS. Diane Sherman. Childrens Press. 1965. Lower Intermediate. 61 pages. Informational.

An introductory book about oceanography. Explains the ocean's beginnings, the interaction of sea and land, the ocean floors, and movements of the oceans. Discusses discoveries from the sea and future possibilities for new uses of the ocean and its resources. Pastel drawings are used to illustrate this book.

YOU CAN MAKE SEASIDE TREASURES. Louis Beetschen. Pinwheel Books. 1971. Middle School and others. 32 pages. Informational. #102

Describes a number of arts and crafts activities that can be done with sand and other items commonly found on beaches. Included are sand molding, making shell necklaces, painting pebbles, building sand castles, and collecting shells. Also includes games to be played at the beach.

YOU WILL LIVE UNDER THE SEA. Fred and Marjorie Phleger. Random House. 1966. Primary. 61 pages. Informational.

A description about a visit to what the underwater world may really be like. A futuristic picture about what life may be like under the sea. Colorful pictures help make "future happenings" understandable to the beginning reader.

LIST OF SUGGESTED FILMS

All films on this list (except where otherwise indicated), may be obtained without charge by writing to:

Motion Picture Service
Department of Commerce -- NOAA
12231 Wilkins Avenue
Rockville, Maryland 20852
(301) 443-8411

THE BIOLOGIST AND THE BOY. 14 minutes. An encounter between a biologist and a boy on the Gulf of Mexico. Discusses conservation and awareness.

ESTUARINE HERITAGE. 28 minutes. Shows threats to estuarine resources and stresses the importance of estuaries.

ESTUARY. 28 minutes. Stresses the value of the estuary and its uses for food resources and recreation.

THE GREAT AMERICAN FISH STORY. 28 minutes. A series of five films (each is 28 minutes long) which tells the story of the American fishing industry. The first film is an overview and the other four each concentrate on one area of the country -- The West, The Northeast, The South, The Lakes and Rivers. Every aspect of the fishing industry is covered from catching to cooking.

HURRICANE. 27 minutes. Shows warning methods for hurricanes. Emphasizes safety precautions for life and property. To obtain: Film Librarian, Public Relations and Advertising Dept., Aetna Life and Casualty, 151 Farmington Ave., Hartford, Conn. 06115. (203) 273-0123.

HURRICANE DECISION. 14 minutes. A hurricane awareness and preparedness film. Points out the dangers of storm surge, wind and inland flooding caused by hurricanes.

IT'S YOUR COAST. 28 minutes. Discusses coastal zone problems with people from Florida, Maine, Illinois and Washington. Land development, oil pollution, and beach erosions are discussed. Stresses the importance of the coast.

WATERMEN OF CHESAPEAKE. 28 minutes. A film about the impact of Chesapeake Bay on a large segment of America.

GAMES

THE THERMAL POLLUTION GAME. Educational Research Council of America, a board game for 4 players about the pollution over time of two rivers in "Central City."

DIRTY WATER. Judith Anderson, Helen Trilling, and Richard Rosen; Urban Systems, Inc., a board game for grades 4 to 12 for 2 to 4 players about the problems of maintaining an ecologically balanced lake.

WHERE TO OBTAIN DATA*

The following paragraphs give detailed information on the types of data available from different sources and show how to obtain it.

1. EARTH RESOURCES OBSERVATION SYSTEM (EROS)

Earth resource data can be obtained by writing to the EROS Data Center, a division of the Department of the Interior.

EROS
Data Management Center
Sioux Falls, SD 57190

The EROS Data Center will assist in locating imagery and photography to suit the particular needs of the user. The center's computerized storage and retrieval system is based on geographical coordinates (latitude and longitude), the date and time of day the photographs were obtained, and the scale of the photographs.

The requestor may provide the center with the latitude and longitude of the point of interest, or may define an area by giving latitude and longitude of a maximum of eight perimeter points. On receipt of a request the center staff will locate the area of interest and will prepare a listing of photographs from which the requestor can make the final selection.

EROS stocks Skylab photographs as well as LANDSAT (ERTS) photographs. The Skylab spacecraft operated at about half the altitude of LANDSAT. Consequently Skylab photographs contain more detail than LANDSAT.

If you elect to use Skylab photographs in your study, it is possible to help EROS speed up your order by quoting the specific photograph numbers of the scene you need. You can write to the following address for help.

Lyndon B. Johnson Space Center
Research Data Facility
Mail Code TF-8
Houston, TX

Include the names of prominent features in the area. City names, rivers, and mountains should be included as well as latitude and longitude. Research Data Facility personnel will check through their catalogs and provide you with photograph identification numbers that you can then send to EROS to obtain the copies you need.

*National Aeronautics and Space Administration, What's the Use of Land? A Secondary School Social Studies Project (Jefferson County, Colorado, Public Schools), 1976, pp. 32-35. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.45, Stock Number 033-000-00665-9).

At the time of writing the prices of black and white EROS photographs ranged from $1.25 to $9.00. Color reproductions cost about three times as much as black and white. For more details write to EROS at Sioux Falls, South Dakota.

Another outlet for EROS services is located in Bay St. Louis, Mississippi. At the National Space Technology Laboratories, anyone can obtain a wide variety of earth resources information and order photographs by writing to:

National Space Technology Laboratories
Bay St. Louis, MS 37520

2. U. S. GEOLOGICAL SURVEY

U.S. Geological Survey (USGS) maps are available from any regional Federal Center and from certain commercial stores such as sporting goods stores. The most common USGS maps are of an area 7½ minutes square or 15 minutes square.

3. SKYLAB EARTH RESOURCES DATA CATALOG

The Skylab Earth Resources Data Catalog prepared by NASA, provides a complete index of Skylab earth resources photographs and other data, plus direction on how copies can be obtained. It also provides a discipline-by-discipline review of possible uses of the Skylab photographs and data with appropriate illustrations.

In marine resources data, channels, shallow areas, river discharges of sediment, and other features of waterways often show up better from space than by any other means.

The environment data deal, in a broad sense, with man's environment. The data also proved particularly useful regarding specific environmental problems. Sources of water and air pollution often can be located and the spread of contaminants traced for long distances in a single photograph.

The Skylab Earth Resources Data Catalog is obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Price $12.50). The book number is GPO-3300-00586.

WHERE TO GET INFORMATION?

Federal Sources of Information

Numerous Federal agencies are involved in matters affecting the coastal zone. Many have special expertise and information that will be of use to citizens who are participating in the development of state management plans. For example they may have data that permits state information to be cross-checked or supplements it with a regional or national perspective. The following are some of the best sources of information.

Office of Coastal Zone Management/NOAA
3300 Whitehaven Street, N.W.
Washington, D.C. 20235
(clearinghouse for specialized coastal zone technical information)

U.S. Fish and Wildlife Service
Washington, D.C. 20240
(can provide information on local waterfowl, game fish and endangered species)

National Marine Fisheries Service/NOAA
Page Building 2
3300 Whitehaven Street, N.W.
Washington, D.C. 20235
(data on commercial and sport fisheries)

Office of Sea Grant/NOAA
3300 Whitehaven Street, N.W.
Washington, D.C. 20235
(supports a large program of university research on ocean and coastal topics)

Department of Agriculture
Federal Soil Conservation Service and Cooperative Extension Agents
Washington, D.C. 20250
(can supply hydrological and soil data, also helpful in providing names of local experts and scientists)

State Coastal Management Program Managers

NORTH ATLANTIC REGION

Connecticut: Charles McKinney, Director, Coastal Area Management Program, Department of Environmental Protection, 71 Capitol Avenue, Hartford, CT 06115

Maine: Alec Griffen, State Planning Office, Resource Planning Division, 189 State Street, Augusta, ME 04333

Massachusetts: S. Russell Sylva, Assistant Secretary, Executive Office of Environmental Affairs, 100 Cambridge Street, Boston, MA 02202

New Hampshire: Larry Goss, Division of Regional Planning, Office of Comprehensive Planning, State Annex, Concord, NH 03301

New Jersey: David Kinsey, Chief, Office of Coastal Zone Management, Department of Environmental Protection, P.O. Box 1889, Trenton, NJ 08625

New York: Robert Hanson, Director, Division of State Planning, Department of State, 162 Washington Street, Albany, NY 12231

Rhode Island: Daniel Varin, Statewide Planning Program, Department of Administration, 265 Melrose Street, Providence, RI 02907

SOUTH ATLANTIC REGION

Delaware: David Hugg, Coastal Management Program, Office of Management, Budget and Planning, James Townsend Building, Dover, DE 19901

Georgia: James Dodd, Planning Division, Office of Planning & Budget, 270 Washington Street, S.W., Room 613, Atlanta, GA 30334

Maryland: Suzanne Bayley, Department of Natural Resources, Energy & Coastal Zone Administration, Tawes State Office Building, Annapolis, MD 21401

North Carolina: Ken Stewart, Department of Natural & Economic Resources, Box 27687, Raleigh, NC 27607

South Carolina: Wayne Beam, Wildlife and Marine Resources Department, 1116 Bankers Trust Tower, Columbia, SC 29201

Virginia: Don W. Budlong, Office of Commerce and Resources, 5th Floor, Ninth Street Office Building, Richmond, VA 23219

GULF/ISLANDS REGION

Alabama: Dr. Bruce Trickey, Executive Director, Coastal Area Board, General Delivery, Daphne, AL 36526

Florida: Dr. Ted LaRoe, Bureau of Coastal Zone Planning, Department of Environmental Regulation, 2562 Executive Center Circle East, Montgomery Building, Tallahassee, FL 32301

Louisiana: George A. Fischer, Secretary, Department of Transportation and Development, P.O. Box 44486, Baton Rouge, LA 20804

Mississippi: Jerry Mitchell, Mississippi Marine Resources Council, P.O. Drawer 959, Long Beach, MS 39560

Puerto Rico: Frank A. Molther (Acting), Department of Natural Resources, P.O. Box 5887, Puerto de Tierra, PR 00906

Texas: Ron Jones, Director, Texas Coastal Management Program, General Land Office, 1700 N. Congress Avenue, Austin, TX 78711

Virgin Islands: Darlan Brin, Virgin Islands Planning Office, P.O. Box 2606, Charlotte Amalie, St. Thomas, VI 00801

GREAT LAKES REGION

Illinois: Chris Shafer, Illinois Coastal Zone Management Program, 300 N. State Street, Room 1010, Chicago, IL 60610

Indiana: T. "Ted" Pantazis, State Planning Services Agency, 143 West Market Street, Harrison Building, Indianapolis, IN 46204

Michigan: Merle Raber, Coastal Zone Management Program, Department of Natural Resources, Division of Land Use Programs, Stephen T. Mason Building, Lansing, MI 48926

Minnesota: Roger Williams, State Planning Agency, Capitol Square Building, 550 Cedar Street, Room 100, St. Paul, MN 55155

Ohio: Bruce McPherson, Department of Natural Resources, Division of Water, 1930 Belcher Drive, Fountain Square, Columbus, OH 43224

Pennsylvania: George E. Fogg, Chief, Division of Outdoor Recreation, Department of Environmental Resources, Third & Reily Sts., P.O. Box 1467, Harrisburg, PA 17120

Wisconsin: Al Miller, Office of State Planning & Energy, One West Wilson St., B-130, Madison, WI 53702

PACIFIC REGION

Alaska: Glenn Akins, Policy Development & Planning Division, Office of the Governor, Pouch AD, Juneau, AK 99801

California: Joe Bodovitz, California Coastal Zone Conservation Commission, 1540 Market Street, San Francisco, CA 94102

Guam: David Bonvouloir, Bureau of Planning, Government of Guam, P.O. Box 2950, Agana 96910

Hawaii: Dick Poirier, Department of Planning & Economic Development, P.O. Box 2359, Honolulu, HI 96804

Oregon: Jim Ross, Land Conservation & Development Commission, 1175 Court St., N.E., Salem, OR 97310

Washington: Rod Mack, Department of Ecology, State of Washington, Olympia, WA 98504

SEA GRANT INSTITUTIONS

Pam Johnson and Linda Weimer have summarized Sea Grant activities and publications that are relevant to elementary and secondary schools. Write for Informal Survey of K-12 Publications. University of Wisconsin, Sea Grant College Program, 1800 University Avenue, Madison, WI 53706, July 1977. Information may also be requested directly from state Sea Grant Marine Advisory Services.

Alaska: Marine Advisory Service, 3211 Providence Avenue, Anchorage, AK 99504

Alabama: Resource Use Division, Cooperative Extension Service, Auburn University, Auburn, AL 36526

California: Marine Advisory Program, University of California, Davis, CA 95616

Connecticut: Marine Advisory Service, University of Connecticut, 322 N. Main Sreeet, Wallingford, CT 06492

Delaware: Marine Advisory Service, College of Marine Studies, University of Delaware, Newark, DE 19711

Florida: Marine Advisory Program, 3002 McCarty Hall, University of Florida, Gainesville, FL 32611

Georgia: Sea Grant Program, University of Georgia, 110 Riverbed Road, Athens, GA 30602

Hawaii: Sea Grant Programs Office, University of Hawaii, Spalding Hall, Room 255, 2540 Maile Way, Honolulu, HI 96822

Louisiana: Sea Grant Program, Coastal Studies Building, Louisiana State University, Baton Rouge, LA 70803

Maine: Cooperative Extension Service, Univ. of ME Marine Lab., Walpole, ME 04573

Maryland: Cooperative Extension Service, 1124 Symons Hall, University of Maryland, College Park, MD 20742

Massachusetts: MIT Sea Grant Program, MIT, Room 1-211, 77 Massachusetts Avenue, Cambridge, MA 02139

Michigan: Coordinator, Advisory Service, Michigan Sea Grant, 2200 Bonisteel Boulevard, University of Michigan, Ann Arbor, MI 48105

Minnesota: Marine Advisory Service, 325 Administration Building, University of Minnesota, Duluth, MN 55812

Mississippi: Sea Grant Advisory Service, Box 4557, Biloxi, MS 39531

New Jersey: Marine Science Center, Rutgers University, New Brunswick, NJ 08903

New Hampshire: UNH Sea Grant Marine Advisory Service, Kingsbury Hall, University of New Hampshire, Durham, NH 03824

New York: NY Sea Grant Advisory Service, Fernow Hall, Cornell University, Ithaca, NY 04853

North Carolina: Extension & Public Service NC State University, 133, 1911 Building, Raleigh, NC 27607

Ohio: Extension Wildlife Specialist, 232 B Howlett Hall, 2001 Flyffe Center, Ohio State University, Columbus, OH 43210

Oregon: Marine Advisory Program, OSU Marine Science Center, Newport, OR 97365

Pennsylvania: Urban Forest Wildlife Specialist, 11 Ferguson Building, Pennsylvania State University, University Park, PA 16802

Rhode Island: Marine Advisory Service, University of Rhode Island, Narragansett Bay Campus, Narragansett, RI 02882

South Carolina: Marine Resources Center, P.O. Box 12559, Charleston, SC 29412

Texas: Education & Advisory Services, Center for Marine Resources, Texas A & M University, College Station, TX 77843

Virginia: Dept. of Advisory Services, Virginia Institute of Marine Science, Gloucester Point, VA 23062

Washington: Washington Sea Grant Marine Advisory Program, University of Washington-HG30, Seattle, WA 98195

Wisconsin: Advisory Services, 420 Lowell Hall, 610 Langdon Street, Madison, WI 53706

RESOURCES FOR COASTAL STUDIES

CURRICULUM MATERIALS CATALOGS

A Catalog of Curriculum Materials for Marine Environment Studies: Elementary, Secondary. 38 pages, $1.00

A List of Books on the Marine Environment for Children and Young People. Annotated, 65 pages, $2.00

Audio-Visual Aids, Games, and Art for Marine Environment Studies. Annotated, 89 pages, $2.00

An annotated Bibliography of Periodical Sources for Marine Environment Studies, Newsletters, Bulletins, Journals, and Magazines. 21 pages, $1.00

All these are available from Project COAST, 310 Willard Hall, University of Delaware, Newark, DE 19711

A Bibliography of Elementary and Secondary Marine Science Curriculum Projects and Education Materials. University of Rhode Island Marine Bulletin Series #15. 23 pages, New England Marine Resources Programs, Narragansett, RI 02882

A Partial Bibliography for Precollege Marine Science Educators. 94 pages, University of Maine Sea Grant. Orono, ME 04473

NON-SCHOOL ORGANIZATIONS

League of Women Voters
1730 M Street, N.W.
Washington, D. C. 20036

Brochures: Coastal Zone Management.1975
The Onshore Impact of Offshore Oil.1976
Energy and Our Coasts: The 1976 CZM Amendments.1977

Florida 4-H
Florida Sea Grant
Florida Maine Advisory Program
University of Florida
Gainesville, Florida

Study: Interest in coastal states in developing marine education programs.

Call : Local Department of Agricultural Extension Service for information on local 4H marine education projects.

Marine Ecological Institute
811 Harbor Boulevard
Redwood, California 94063

Discovery marine voyages: Around San Francisco area, fee.

Jean-Michel Cousteau Institute
P. O. Drawer CC, Harbor Town
Hilton Head Island, South Carolina

Workshops: "Man and the Sea" in Savannah, Georgia and Charleston, South Carolina, fee.

Coastal Management Programs
Coastal States

Newsletter: Describes local coastal problems, issues and proposed solutions. For addresses see list of state coastal management programs in section on "Where to Get Information".

ASSISTANCE IN COASTAL AND MARINE EDUCATION

National Marine Education Association
546-B Presidio Boulevard
San Francisco, California 94120

Newsletter and Annual Conference: Contact Thayer Schafer, Exec. Secy.
Membership $15

Sea World (Formerly, The Journal of Marine Education)
Sea World Communications
1250 Sixth Avenue
San Diego, California 92101

Magazine: Published quarterly, includes section on curriculum (included in $15 membership in National Marine Education Association).

Marine Education Materials System
Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

Microfiche copies of marine education materials; Inexpensive, ask for list of materials available.

. Francis Pottenger
Curriculum Research and Development Group
College of Education, University of Hawaii
1776 University Avenue
Honolulu, Hawaii 96822

Coastal Studies Course: Designed for 11th and 12th graders, includes ecology, economics, and government and involves students in coastal issues and management systems. Write for information on the course and teacher training.

GLOSSARY

GLOSSARY:

Algae:
Simple aquatic plants, without true stems, leaves, or roots, that vary in size from microscopic, unicellular forms to multicellular forms more than 30.5m (100 ft) long

Arthropods:
Segmented invertebrates with jointed legs, including arcachnids insects, and crustaceans

Barrier islands:
Low offshore islands stretching parallel to the shore and separated from the mainland by a small body of water; in the United States found mainly on the Atlantic coast (from New Jersey south), along the Gulf of Mexico, and in the Pacific only in north Alaska and in an area along the coast of northern Oregon and southern Washington

Bay:
A wide inlet of water, indenting the shoreline and forming a protected area along the shore of a sea or lake

Bayou:
A marshy, sluggish tributary to a lake or river; from the Louisiana French version of the Choctaw word bayuk

Beach:
A shoreline area washed by waves and composed of sand or pebbles

Beach grass:
A strongly rooted plant common on sandy shores that helps to anchor and build the dunes

Berm:
A narrow shelf, path, or ledge typically at the top or bottom of a slope.

Breakwater:
A barrier constructed of large rocks or concrete to provide protection for beaches or harbors by breaking the force of wave action. Groins, jetties, and sea walls are all forms of breakwaters

Coast:
Land next to the sea; seashore

Coastal management:
The development of policies and regulations to insure wise control, development, and use of coastal resources

Coastal pond complex:
A land and water composite that consists of a barrier beach, sand dunes, marsh, and pond; small off-shore islands and freshwater streams and wetlands are sometimes included

Coastal resources:
Anything that gives a source of supply, support, or aid in maintaining the value of the coastal region. The value can be counted in various terms: monetary (oil, ports, fish), ecological (plankton, dunes, shorebirds), cultural (historic areas), aesthetic (scenic bluffs, clear blue water) or recreational (marinas, beaches)

Continental shelf:
The ocean floor along the coastline that is submerged in the relatively shallow sea; the sunlit, submerged land from the coast to the brink of the deep ocean

Coral reef:
A colony of marine animals with skeletons containing calcium carbonate that, massed together, form islands or ridges near the surface of the sea in tropical areas (found only in Florida and Hawaii in the United States)

Crustacean:
Any mostly aquatic arthropod, typically with a hard shell covering the body; includes lobsters, shrimps, crabs, and barnacles

Delta:
The area where river sediment is dropped at the mouth of a river flowing into an ocean or large lake; frequently triangular in shape made up of marshy areas, lagoons, and lakes

Detritus:
A sediment of small particles found on the ocean bottom made up of the remains of plants and animals and the disintegration of rocks; an important link in many food chains

Dock:
A platform extending into the water to which a boat is tied or where passengers and gear are loaded or unloaded

Downdrift:
Describes direction of sand movement with the prevailing current

Dune:
Elliptical or crescent-shaped mound of sand formed by wind action. The windward slopes of dunes are gentle, the lee sides steep. In crescent-shaped dunes the convex side faces the direction from which the wind is blowing. Sand blown up the windward side drops down the lee slope, causing the dunes to migrate slowly

Eelgrass:
A grasslike marine herb with ribbonlike leaves that grows on sand and mud-sand bottoms in shallow coastal waters

Estuary:
The zone where the fresh water of a river mixes with the salt water of the sea; rich in biological activity

Flood plain:
The flat area along a river that is subject to flooding at high water periods

Food chain:
A series of organisms in which members of one level feed on those in the level below it and are in turn eaten by those above it; there is a 10 to 1 loss in bulk as the food chain moves upward. It takes a 1000 kilograms of phytoplankton to make 1 kilogram of shark

Food web:
The interconnected food chains of a biological community

Groin:
Breakwater structure constructed outward into the sea or a lake to reduce drifting of beach sand along the shore

Harbor:
A sheltered area of water deep enough for ships to anchor or moor for loading and unloading; may be natural (bays) or artificial (within breakwaters)

Intertidal zone:
The area along the shoreline that is exposed at low tide and covered by water at high tide

Island:
A body of land completely surrounded by water and too small to be called a continent

Isopod:
Any fresh-water, marine, or terrestrial crustacean having seven pairs of legs and a flat body

Jetty:
A pier or structure projecting into the water to protect a harbor or deflect a current

Lagoon:
A body of brackish water separated from the sea by sandbars or coral reefs

Lake:
A large body of fresh or salt water completely surrounded by land

Littoral:
Pertaining to the shore of a lake, sea, or ocean

Mangrove:
A moderate-sized tree which grows on low, often submerged coastal lands, noted for the land-forming function of its intricate mass of arching prop roots which trap silt and debris floating in the water

Ocean:
The entire body of salt water (seawater) that covers almost three-fourths of the earth's surface

Oil rig:
A structure for drilling and pumping oil from beneath the ocean floor to the water's surface

Pier:
A fixed or floating platform attached to piles or posts over the water from the shore; may be used for mooring boats or ships, fishing, etc.

Pond:
A body of still water, fresh or salty, that is smaller than a lake; frequently constructed to hold water

Port:
A town or city located at a bay or harbor where waterborne transportation takes place; from the Latin for house door

Riprap:
Broken stone or other material piled along a shore to protect it from erosion by wave action

River:
A fairly large-sized natural stream of water flowing in a definite course from an area of higher elevation to lower elevation. The term "river" is sometimes used incorrectly to define narrow tidal inlets

Rocky cliff:
The high steep face of a rock mass that forms the most erosion-resistant areas along the shore

Salinity:
The measure of the quantity of dissolved salts in seawater

Salt marsh:
An area of low-lying, wet land with heavy vegetation that is washed by tidal action from the sea

Sand:
A mixture of tiny grains of different types of disintegrating rocks and shells found along beaches

Sandbar:
An off-shore shoal of sand resulting from the action of waves or currents

Sea wall:
A barrier constructed along the edge of a shore to prevent erosion from wind or wave action; sometimes called bulkhead or revetment

Seawater:
The water of the ocean which is distinguished from fresh water by its salinity

Seaweed:
Any plant growing in the sea, specifically marine algae like kelp, rockweed, and sea lettuce

Shore:
The space between the ordinary high water and low water marks

Shoreline:
Where the land and water meet

Sound:
A narrow passage of water forming a channel between the mainland and an island or connecting two larger bodies of water such as a bay and an ocean

Spit:
A narrow point of land extending into the sea or a lake formed by waves and currents; subject to shifting

Tide:
The twice-daily rise and fall of the waters of the ocean and its inlets produced by the gravitational attraction of the moon and sun

Tidal pool:
A small body of water along rocky shores left by the retreat of the tide; a unique environment for many plant and animal species that can withstand highly variable moisture, salinity, and temperature conditions as well as high winds and pounding waves

Trophic:
Having to do with nutrition

Wave-cut cliff:
The steep slope of the shore cut by wave action

Wetlands:
Areas such as fresh and salt-water marshes, bogs, or swamps that remain wet and spongy most of the time

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